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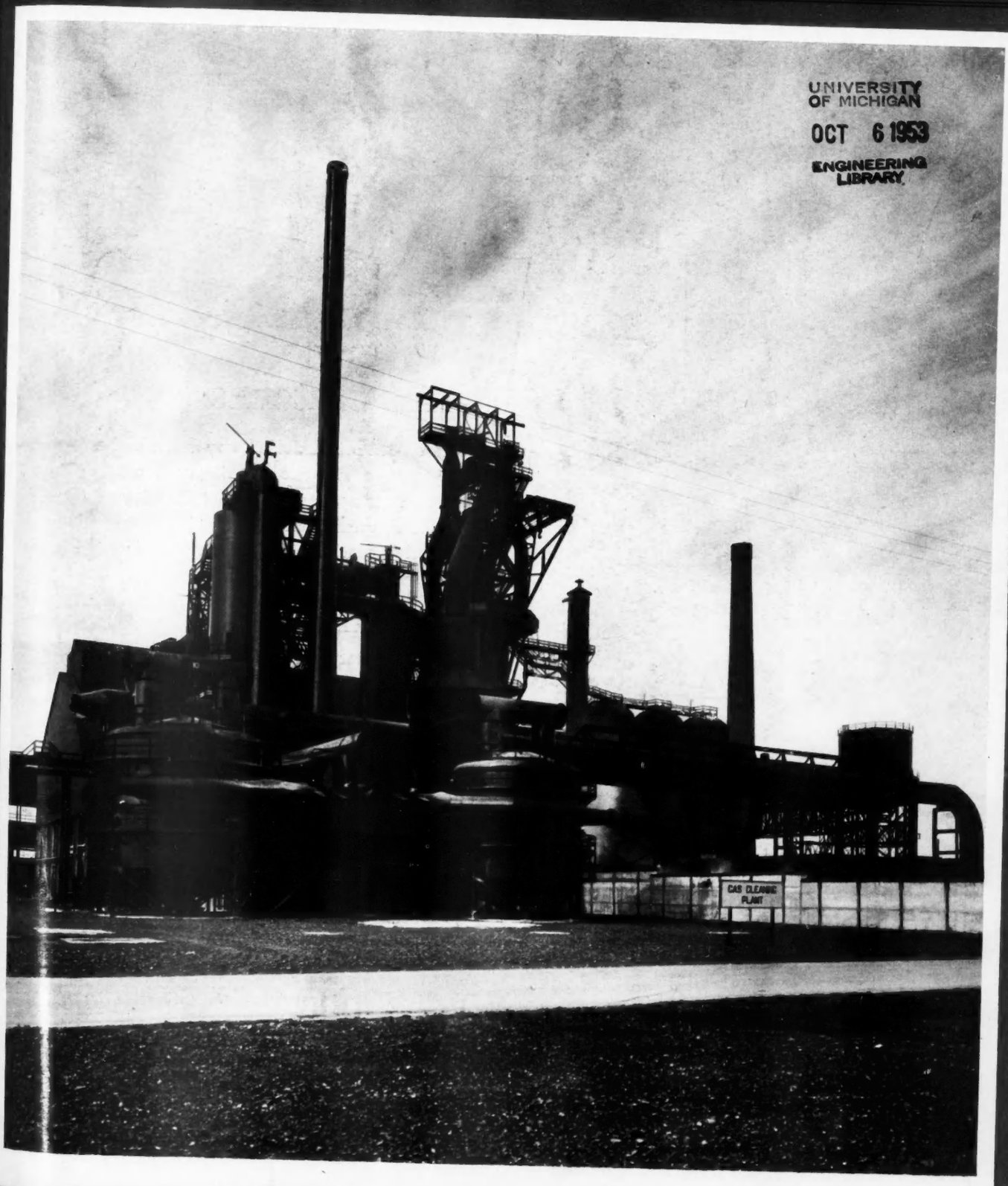

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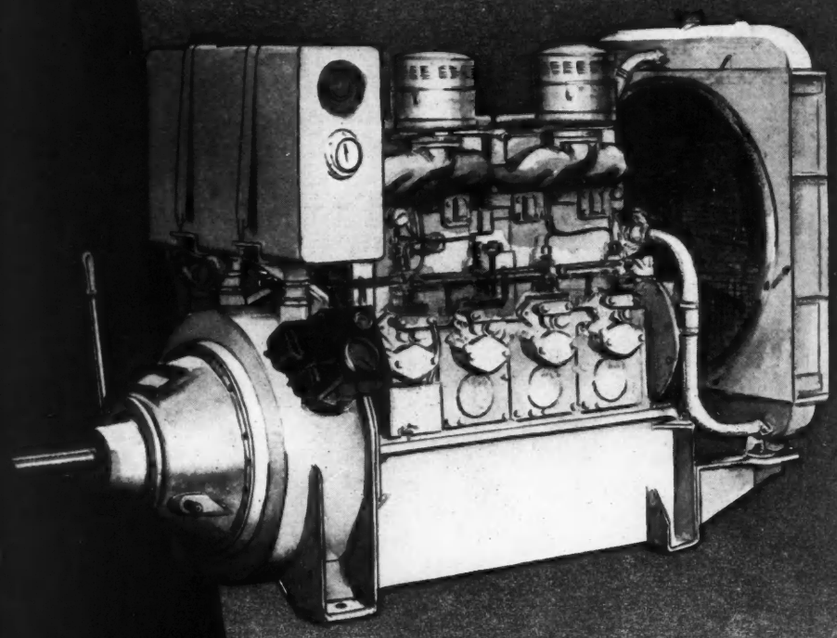

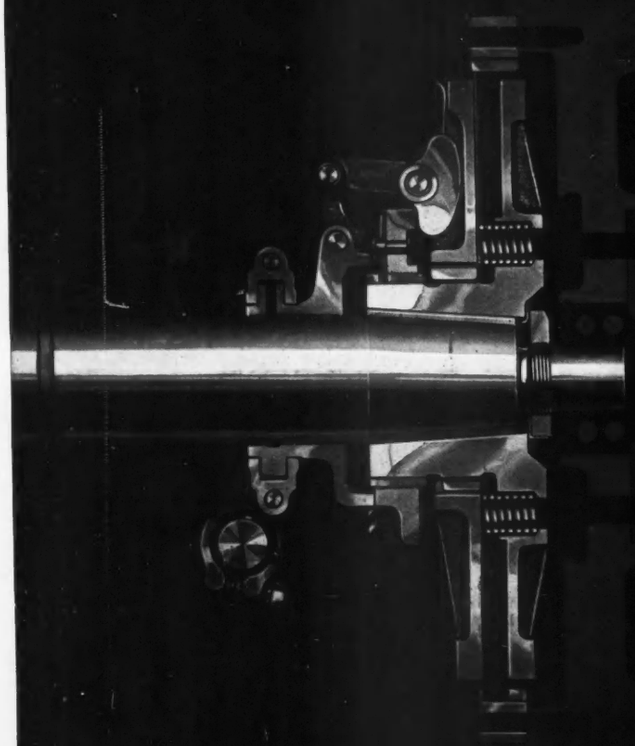

Power take-offs and clutches

Rockford British-made heavy-duty clutches and power take-offs are being used to a rapidly increasing extent on industrial petrol, paraffin and diesel engines, and on machines such as portable air compressors, power shovels, pumps, excavators, winches and cranes.

These heavy-duty clutches have several important features, including an actuation system which maintains the clutch in either the engaged or the disengaged position, and in each case without running thrust.

The upper illustration shows the MacLaren power pack, embodying a Rockford unit with single-plate clutch.

Descriptive booklet, with list of standard sizes, on application from :—
BORG & BECK COMPANY LIMITED,
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ROCKFORD

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA,

INCORPORATING THE CHEMICAL PLANT EXHIBITION.

(*Continued from page* 329.)

THE exhibits at the Engineering, Marine and Welding Exhibition (which closes on September 17) reached a very high standard of design and workmanship. To the casual visitor changes in design, in most fields, may seem to be almost imperceptible, but anyone touring the stands with a clear need or interest quickly found that improvements abound, particularly in testing and other techniques. In this article we describe a further selection of exhibits.

FRACTIONAL HORSE-POWER MOTORS.

Hoover Limited, Perivale, Middlesex, show their range of fractional horse-power motors, which for the last three years they have been manufacturing at Cambuslang, Lanarkshire. These motors conform with British Standard Specification No. 170/1939 and, in addition, the four-pole capacitor-start motors in the range comply with the special refrigerator appendix. As regards construction, the stator laminations are die-cast into the body, which is provided with air ducts to ensure an ample flow of air. The temperature rise is therefore well within the specified margin. There are generous registers on the end frames, thus ensuring positive location with the stator spigots and giving a robust unit, which is capable of withstanding modern transport conditions. The end frames are also die-cast and have been designed so that they incorporate the air cone and wind shield and thus facilitate assembly. The rotor laminations are stamped from the same high-grade steel as the stator, while the squirrel cage, end rings and fans are die-cast from pure aluminium. Either sleeve or ball bearings can be used and provision has been made for infrequent lubrication.

The drip-proof range of these motors has outputs from $\frac{1}{8}$ to $\frac{1}{2}$ h.p. single-phase and up to $\frac{3}{4}$ h.p. three-phase at speeds of 950, 1,425 and 2,850 r.p.m. A range of totally-enclosed motors is also made.

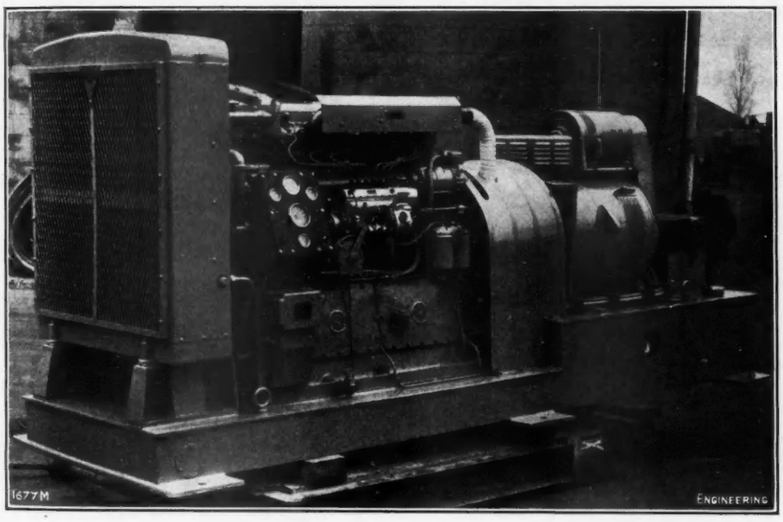


FIG. 109. 60-KW DIESEL GENERATOR SET; A.E.C., LTD.

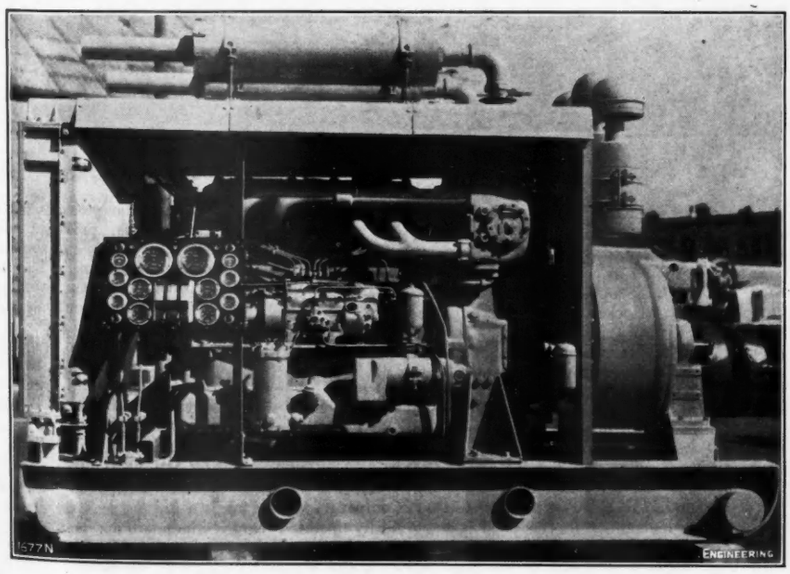


FIG. 110. 11·3-LITRE DIESEL "POWER PACK"; A.E.C., LTD.

60-KW DIESEL GENERATOR SET.

The A.C.V. Group are exhibiting three 9·6-litre six-cylinder Diesel engines, and a twin 11·3-litre industrial unit of over 250 h.p., designed specifically for oilfield duties, all being manufactured by A.E.C., Limited, Southall, Middlesex. The 9·6-litre engines are shown as the Type A210 marine engine, with reverse gear and a 3 : 1 reduction gear; as the Type A224 self-contained 60-kW generating set, as shown in Fig. 109, and also as the Type A219 horizontal rail traction engine, complete with a fluid flywheel, epicyclic transmission and a final-drive unit, the whole designed for under-floor installation between bogies. Certain features of the 9·6-litre engines are identical and all are six-cylinder engines with a bore and stroke of 120 mm. (4·72 in.) and 142 mm. (5·59 in.), continuously rated at 100 h.p. at 1,500 r.p.m. The cylinder block is a single casting fitted with dry liners and the pistons are of heat-treated aluminium alloy; each is fitted with two oil-scraper and three compression rings, the lower oil-scraper ring being below the gudgeon pin. The Ricardo combustion recess is machined in the piston crown and fully-floating hollow gudgeon pins are fitted, being positioned in the pistons by circular clips. The crankshaft has seven main bearings and is fitted with a vibration damper. It is drilled to provide oil-ways for the high-pressure lubrication system to all main and crank-pin bearings. Lubrication is on the wet-sump principle with submerged twin oil pumps, but in the marine version the dry-sump system is substituted, as this ensures against loss of oil pressure due to rolling or pitching of the vessel. The valve gear on all engines is of the push-rod operated overhead type, the timing gears to the camshaft being helically cut and carried in ball-bearing journals. In addition to driving the camshaft, the timing gears provide the drive for the water-circulating pump, dynamo, fuel-injection pump and engine-speed indicator. The instrument panel is equipped with oil and water temperature gauges, an oil-pressure gauge, ammeter, and engine-speed indicator. Mounted in the panel is the starter button and a socket for a 24-volt inspection lamp.

The 60-kW generating set employs a MacFarlane self-regulating alternator. A feature claimed for these units is their ability to accept full load, from a dead-cold start, in 47 seconds. These sets are also constructed for parallel running and a recent multiple installation of sixteen sets, with a total output of 1,200 kVA, is arranged for running in parallel with the local electricity-supply mains.

11·3-LITRE DIESEL "POWER PACK."

The 11·3-litre power pack shown in Fig. 110 has been designed for heavy-duty operation in oil-fields, and other spheres requiring a compact, portable power unit for driving generators, winches, pumps, etc., its mobility being assured by the rigidly-designed skid bedplate. It comprises two self-

contained, handed, A.E.C. six-cylinder 11·3-litre Diesel engines driving a common output shaft through individual plate clutches and a three-spur-gear train. The standard unit incorporates supercharged engines, but normally-aspirated units are also made, with a corresponding reduction in power output. By the use of hand-operated clutches, it is possible to isolate either engine from the drive if necessary. Cooling of the engines is effected by a pair of "Still" tube radiators incorporating separate oil-cooling elements and designed for operation in tropical climates. The unit is made with various output-shaft speed ratios.

1,100-B.H.P. Dual-Fuel Engine.

The English Electric Company, Limited, Kingsway, London, W.C.2, are displaying equipment on three stands at the exhibition. It includes examples of their industria electric motors, among which mention may be made of a range of fractional horse-power units with outputs from ½ h.p. to 1 h.p. at 230/250 and 400/440 volts. A complete range of single- and multi-operator welders is also being shown, while the Ignitron exhibits include two types which are primarily intended for the control of resistance welders, though they are also suitable for the precision control of mass X-ray machines. The electronics department is represented by a new design of high-frequency induction heater and a portable insulation-testing set.

The Diesel engine exhibits include one of five units which are being supplied to the National Coal Board for use in the power station of the Point of Ayr Colliery. These engines have an output of 1,100 b.h.p. at 428 r.p.m., and are basically of the firm's mechanical injection Diesel type, but are equipped with mixing apparatus so that they can be operated either on methane or oil. This mixing apparatus is applied to the air-intake system and is linked to the engine governor. For dual-fuel operation, the normal injection equipment will be utilised to provide a pilot injection of oil for igniting the gas. The quantity of oil thus injected can be varied over a wide range, the balance of heat input being supplied by the methane. Straight Diesel operation wholly on oil can also be employed. To increase the efficiency of the plant as a whole, heat will be transferred from the closed cooling system of the engine to a secondary water circuit through a tubular heat exchanger. The water in this circuit will then pass through a waste-heat boiler where further heat will be recovered from the engine exhaust gases. The hot water thus obtained will be used to supply the pithead baths, space heating, and other requirements. A view of one of the engines is given in Fig. 111.

1,500-H.P. Diesel-Electric Traction Set.

Fig. 112 is an illustration of a 1,500-h.p. Diesel-electric traction set, which is also being exhibited at Olympia and 21 of which are being supplied to the New Zealand Government Railways. The engine has a speed range of 420 to 850 r.p.m. and operates on the four-stroke cycle with solid fuel injection to open-type combustion chambers. The twelve cylinders, which have a 10 in. bore and 12 in. stroke, are arranged in two banks of six at an included angle of 45 deg., and each cylinder head carries two inlet and exhaust valves, a fuel injector and a combined pressure-relief and compression-release device. The two turbo-pressure chargers, which, like the prime mover and electrical plant, were manufactured by Messrs. D. Napier and Son, Limited, Acton, are bracket-mounted over the main generator and consist of a single-stage axial-flow exhaust-gas turbine driving a centrifugal air compressor. Both turbine and compressor are mounted on a common shaft.

The main generator is flange-mounted on the engine crankcase and bedplate, thus forming a single unit which is borne resiliently on the locomotive under-frame. The single-bearing armature suspension which is employed incorporates an extension on which the armature of the auxiliary generator is carried. This auxiliary generator provides excitation for the main generator and supplies the auxiliary services. The engine is started by motoring the main generator from batteries, additional windings being provided for this purpose.

ENGINEERING, MARINE AND WELDING EXHIBITION.

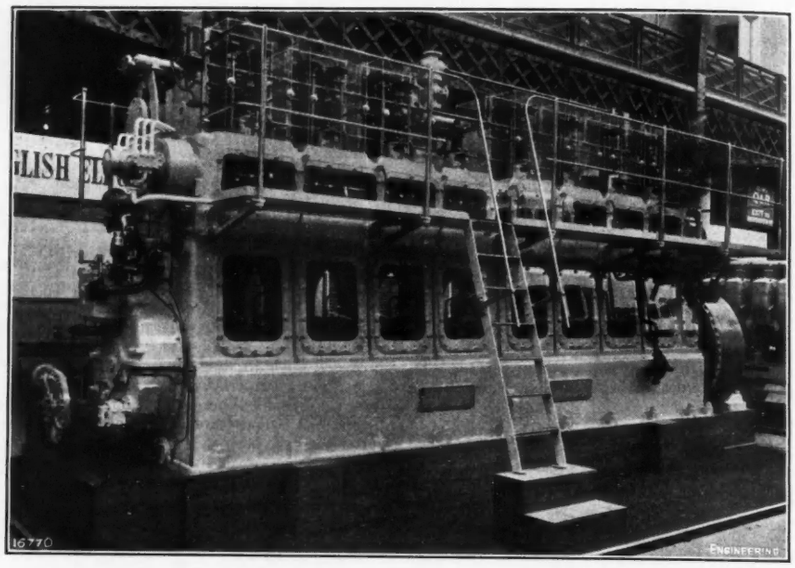


Fig. 111. 1,100-B.H.P. Dual-Fuel Engine; English Electric Co., Ltd.

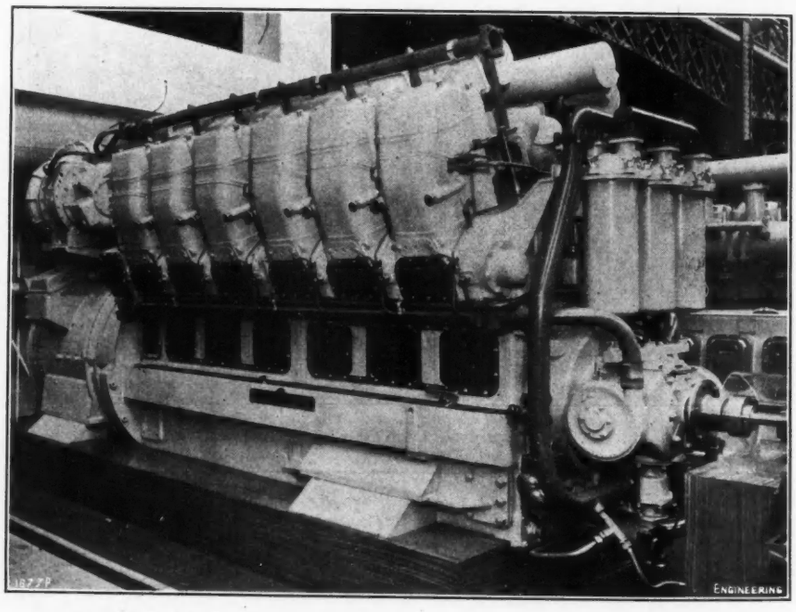


Fig. 112. 1,500-H.P. Diesel-Electric Traction Set; English Electric Co., Ltd.

Coal-Pulverising Mill.

Among the items exhibited by Messrs. Clarke, Chapman and Company, Limited, Gateshead, 8, Co. Durham, is a model of a Raymond bowl mill, illustrated in Fig. 113, opposite. The roll-type feed gear, which is interlocked with the main drive, introduces the coal into a rotating bowl. In this are spring-loaded rollers which crush the coal against the edge. The passage of the coal rotates the rollers, which are never in direct contact with the bowl. Above the bowl is a conical classifier which can be adjusted for fineness. Hot air enters below the bowl and is drawn up and round it by an exhauster fan, carrying the powder up to the classifier. Oversize particles fall back into the bowl. The passage of the air dries the coal so that the average moisture content in the bowl is kept low. Very hot air can be used, as it does not come into direct contact with any of the grinding elements. All controls for the mill are brought outside the casing and adjustments can be made while running. The fact that the pressure inside the casing is below atmospheric, prevents dust escaping into the boiler-room. The controls are well adapted for automatic operation. Because there is no metal-to-metal contact in the grinding, the lives of the parts are prolonged and the mill is quiet in operation. The low speed of rotation—75 to 150 r.p.m., according to size—also assists in this respect. Outputs range from 1 ton to 16 tons per hour. Messrs. Clarke, Chapman and Company are the sole licencees for this mill in Great Britain and the Commonwealth (except Canada).

Self-Contained Cargo Winch.

Another item that Messrs. Clarke, Chapman and Company are showing is a prototype 3-ton hydraulically-operated cargo winch. This is shown in Fig. 114, opposite. It is an entirely self-contained unit, and is powered either by an electric-motor or by a Diesel engine. The motor, or engine, drives a hydraulic pump, which, in turn, operates a

ENGINEERING, MARINE AND WELDING EXHIBITION.

FIG. 113. COAL-PULVERISING MILL; CLARKE, CHAPMAN & CO., LTD.

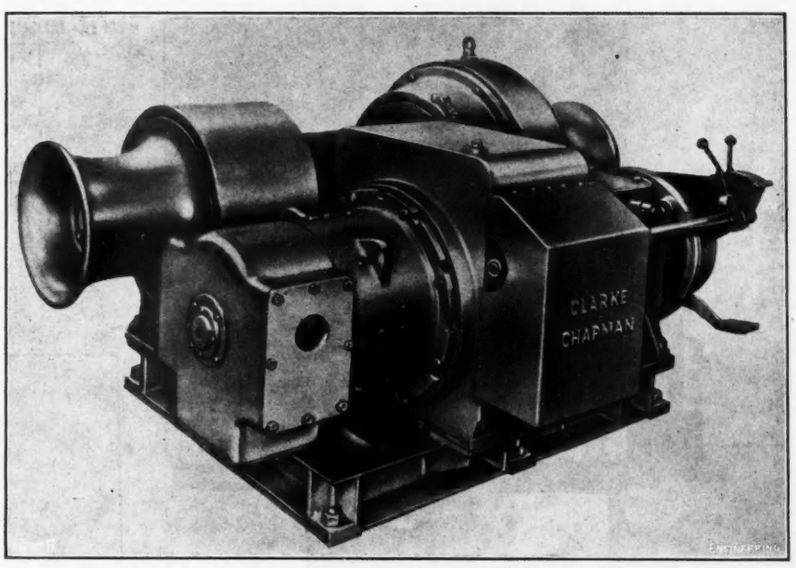


FIG. 114. SELF-CONTAINED CARGO WINCH; CLARKE, CHAPMAN & CO., LTD.

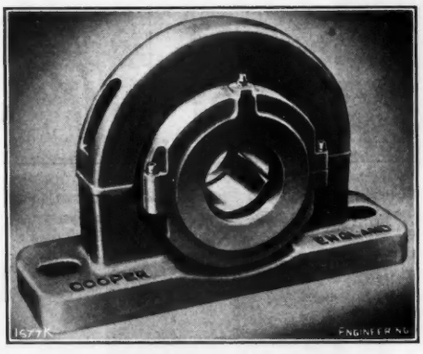


FIG. 115. SPLIT ROLLER BEARING AND HOUSING; COOPER ROLLER BEARINGS CO., LTD.

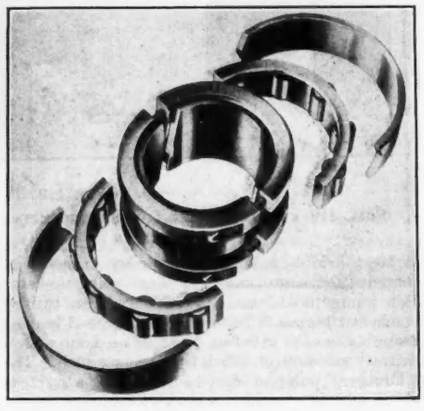


FIG. 116. COMPONENTS OF SPLIT ROLLER BEARING; COOPER ROLLER BEARINGS CO., LTD.

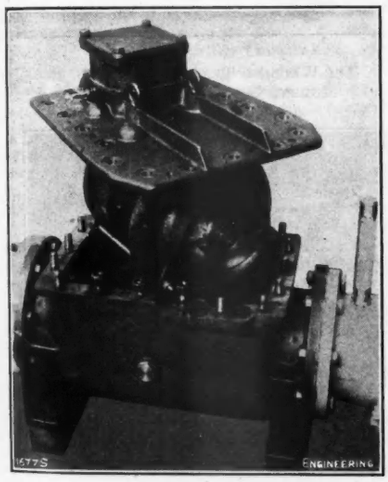


FIG. 117. "CAPSULE" PUMP FOR TRANSFORMER OIL; DRYSDALE & CO., LTD.

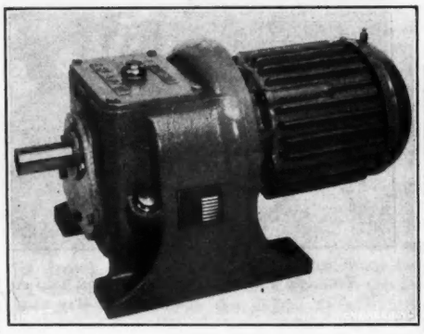


FIG. 118. GEARED MOTOR UNIT; ALFRED WISEMAN & CO., LTD.

hydraulic motor through a control chest. The hydraulic motor then drives the winch through a two-speed spur gearbox. The hydraulic pump and motor are of the radial multi-cylinder type. The control chest has piston valves enabling the load to be lifted at creep speeds or at full speed, suspended, or lowered at any desired speed, while the pump is driven at constant speed throughout. Lowering can also be controlled by the mechanical foot brake. Both the hydraulic motor and the pump are contained in the reservoir tank, and run completely immersed in oil. Overloading is governed by an unloading valve in the control chest. Since all moving parts of this winch run in oil, it is silent in operation and has a very low wear rate.

SPLIT ROLLER BEARINGS.

The Cooper Roller Bearings Company, Limited, King's Lynn, Norfolk, are exhibiting a selection of their split roller bearings for medium, heavy and extra-heavy applications. They range from a bore of 1¼ in. to 17 in. and are being displayed as bearings only and as complete bearing units with self-aligning housings and plummer blocks, as shown in Fig. 115, herewith. The bearings are made in two sections and split across the centre after the manner of a plain split-bearing bush, as shown in Fig. 116. The two halves of the inner race are clamped on to the shaft by Allen-type screws and protect the shaft from wear. To complete the assembly of the bearing, the cage with the rollers and the outer race is placed in position. The joints of the inner and outer races are diagonally shaped to ensure continuity of contact when the rollers pass over them. They are made of high-carbon chromium steel and hardened throughout. The advantage of this bearing is that it simplifies assembly, and therefore design, whilst maintaining the high efficiency of a solid roller bearing. Working models on the stand illustrate its performance, design, and application to marine propeller shafts and other services. Bearings of this nature are employed in steelworks, mechanical-handling, mining, oilwell and many other industries.

"CAPSULE" PUMP FOR TRANSFORMER OIL.

Drysdale and Company, Limited, Glasgow, W.4, are exhibiting a varied selection of marine and land pumps of the centrifugal, rotary, and axial-flow types. One interesting exhibit is the "Capsule" pump, illustrated in Fig. 117, herewith, and primarily intended for the circulation of transformer oil, although other uses will be apparent. This pump is of the axial-flow type and is mounted in a section of piping together with adjacent screw-down valves, and, as will be seen, the motor, to which the impeller is attached, is fixed to the cover plate and runs submerged in the oil being pumped. The advantage of this type of pump, with its inlet and discharge orifices in line, is that by simply closing down the adjacent valves the entire pumping unit may be removed without any loss of oil, nor is any draining of the system necessary

ENGINEERING, MARINE AND WELDING EXHIBITION.

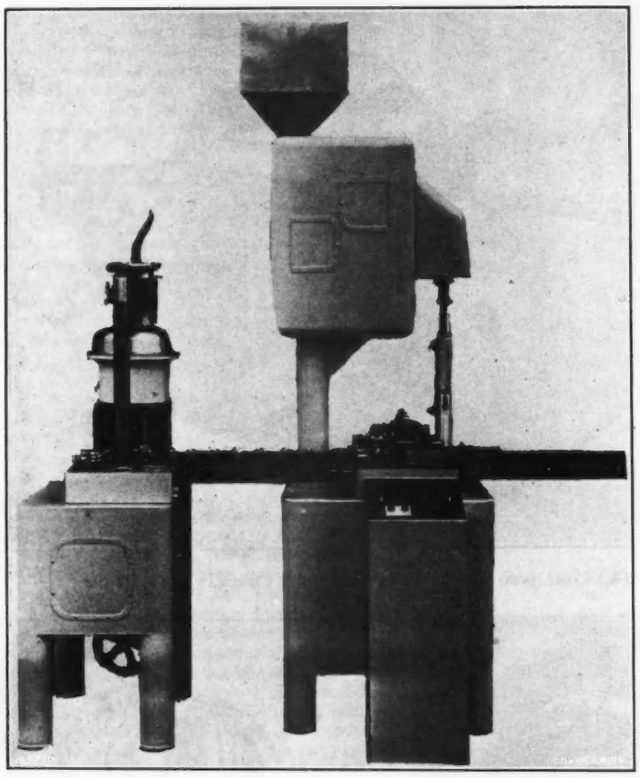
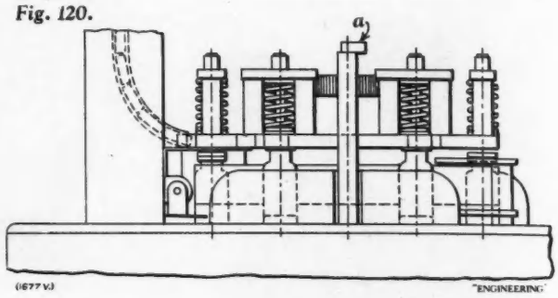


FIG. 119.

FIGS. 119 AND 120. VIAL CAPPER AND SPINNER; FORDS (FINSBURY), LTD.

Fig. 120.



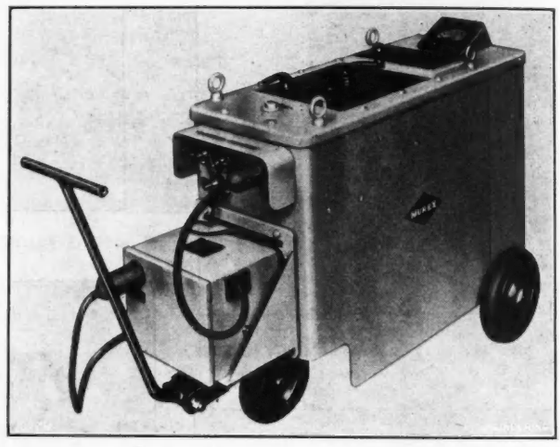


FIG. 121. ARC-WELDING TRANSFORMER; MUREX, LTD.

A large exhibit is a 15-in. two-stage turbo-pump intended for cargo transfer in ocean-going tankers; this pump is driven by a Weir steam-turbine connected horizontally through a bulkhead-bearing assembly, and is rated at 600 tons an hour with a delivery pressure of 125 lb. per square inch. The "Centrex" pump, designed for handling a mixture of air and water, which is shown working, is a combination of a water-ring air pump which handles the air, and a normal centrifugal pump which deals with the water.

GEARED MOTOR UNIT.

Among the several types of gearboxes exhibited by Alfred Wiseman and Company, Limited, 8, Southampton-row, London, W.C.1, is a geared motor unit that has been specially designed to fit totally-enclosed flange-mounted electric motors which conform to British Standard requirements. The range of motors which can be used with these units is from ¾ h.p. up to 25 h.p. The gearboxes themselves are made in ten sizes, either double or triple reduction, giving output shaft speeds of from 20 to 360 r.p.m. for a motor speed of 1,440 r.p.m. The illustration, Fig. 118, on page 355, shows a unit complete with fan-cooled motor. Other items on the stand are: gear-type couplings for either marine or industrial use; a lift-gear drive unit; a worm-reduction bollard drive unit; and resilient gear-wheels for locomotives or other drives where shock loading is encountered.

VIAL-SEALING MACHINE.

A capping machine, with a capacity of 8,000 vials per hour, is among the exhibits of Fords (Finsbury), Limited, Chantry-avenue, Kempston, Bedford; with it is a three-head spinner for closing the caps, having the same capacity. These two machines are shown in Fig. 119, herewith, the capper being on the right, and details of the capping mechanism are given in Fig. 120. Vials, filled and sealed with a rubber bung, are brought by conveyor from the sterilising plant and fed to the lower half of the star-wheel. At the same time, caps are fed to the upper half of the wheel. Before being fed to the wheel, the caps pass through a selector, which ensures that they are the right way up by passing them between a plate and plunger which select one of two delivery chutes according to the position of the cap. One chute twists in its length so that all caps finally arrive the same way up. As the cap and vial rotate with the star-wheel, they are at first held apart by a plate. At the end of this, the vial is lifted by a cam and moves up into the cap. Should the cap not fit, the spring holder above also lifts and, engaging with lever *a*, causes both vial and cap to be ejected. The capped vials are then delivered by a short conveyor to the spinning machine, again being received by a star-wheel. They are then lifted by cam action and, by pressing against the spinning heads, cause the rollers to close in. These heads are driven by an epicyclic train and close in the caps below the rim of the vial. The sealed vials are then ready for the next process. The hopper of the capping machine holds enough caps for eight hours' running, and there are protective devices which operate if the supply of either caps or vials runs out.

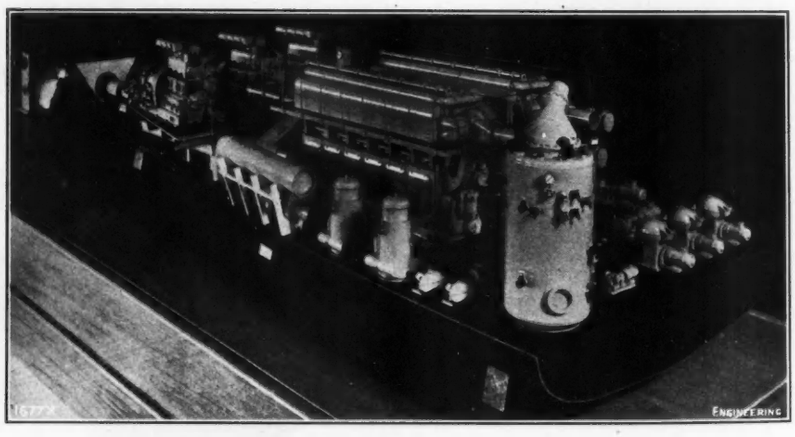


FIG. 122. MODEL OF PROPULSION AND AUXILIARY MACHINERY FOR WHALE CATCHER; NATIONAL GAS AND OIL ENGINE CO., LTD.

ARC-WELDING TRANSFORMER.

Murex Limited, Waltham Cross, Hertfordshire, are showing a range of welding equipment and electrodes, among which is the transformer shown in Fig. 121. This is a single-operator oil-cooled self-contained unit with a current range of 25 to 250 amperes for continuous hand welding and up to

ENGINEERING, MARINE AND WELDING EXHIBITION.

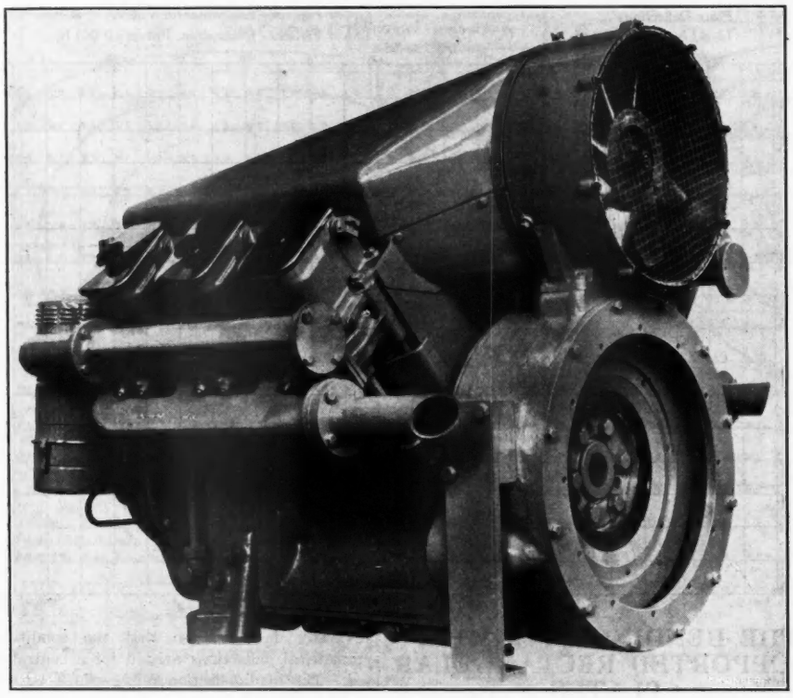


FIG. 123. 60-H.P. MARINE OIL ENGINE; PETTERS, LTD.

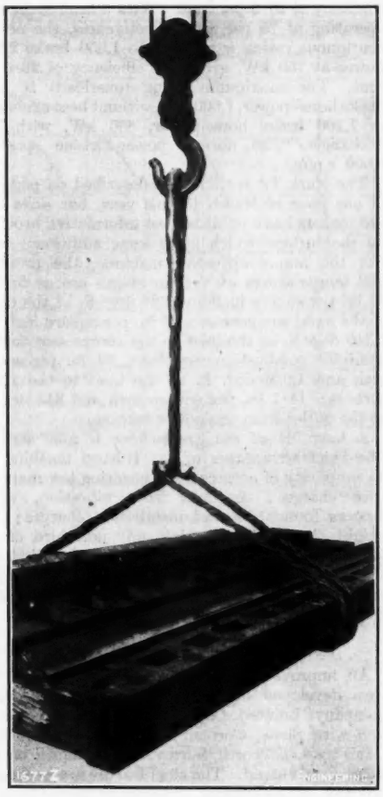


FIG. 124. BRAIDED WIRE-ROPE SLING; BRITISH ROPES, LTD.

375 amperes for intermittent work. It has four current stages, which are selected by a crank handle mounted on the top of the transformer, and 12 different currents can be selected in each stage. There are two open-circuit voltages of 80 and 100 volts, the necessary connections for these being made by a copper link to an "earth and work" terminal. Space is provided for a capacitor for power-factor correction. The equipment, which is suitable for operation at any mains voltage between 200 and 550 volts, is mounted on wheels and is fitted with a drawbar. Another new transformer is a double-operator unit with an output of up to 375 amperes for intermittent work at each position. A paralleling arrangement enables currents up to 500 amperes to be obtained for continuous hand welding and up to 750 amperes for intermittent work. The unit is oil-cooled and self-contained and the tank is mounted on wheels. Four current ranges can be selected and an exact current within them obtained by operating crank handles. The open-circuit voltages are 80 and 100 volts, which are selected by a copper link.

A new arc-welding generator, which is on view, has drooping characteristics and has been designed so that the current can be continuously varied irrespective of the open-circuit voltage. The current range is from 15 to 300 amperes for continuous hand welding and up to 450 amperes for intermittent welding. There are no series resistances and the controls consist simply of a small knob for regulating the shunt field and a cranked handle for adjusting the current. Instruments are eliminated by the use of calibrated indicator plates, and their absence and that of resistances makes a cabinet unnecessary, the controls being built into the top of the end shield. The open-circuit voltage can be varied between 70 and 90 volts, while a polarity-reversing switch enables the welding leads to be permanently connected to the output terminals. The generator is designed so that it can be incorporated in all the firm's motor-generator sets and Diesel-engine and petrol-engine driven equipments.

60-H.P. MARINE OIL ENGINE.

In addition to the exhibits on the stand of the Brush Electrical Engineering Company, Limited, of which mention was made on page 323, *ante*, a number of internal-combustion engines are being shown. These include a new model, manufactured by Petters, Limited, Staines, of which an illustration appears in Fig. 123, on this page. This engine, which has an output of 60 brake horse-power at a speed of 1,500 r.p.m., is of the direct-injection air-cooled type and operates on a four-stroke cycle. The crankcase, which is of cast-iron, is of the split pattern with an aluminium-alloy sump, and the connecting rods have copper-lead lined big-end bearings and fully-floating gudgeon pins. The pistons, which are also of aluminium alloy, incorporate hemispherical combustion chambers and are fitted with two oil-scraper and three compression rings, the uppermost one of which is chromium-plated. To facilitate cooling, the cylinders, which are of special cast-iron, are heavily finned. Separate cylinders and cylinder heads are used, there being through-bolts between the heads and the crankcase. The valves and pressure-lubricated rocker gear are mounted on the cylinder heads. Two camshafts, one for each bank of cylinders, are fitted inside the outer walls of the crankcase. One of these shafts drives a lift pump by which fuel oil is supplied through a fabric-type filter to a dustproof Simms block pump. The latter pump is mounted between the cylinders and is driven through gearing from the crankshaft. A centrifugal governor, which is fitted on the fuel-pump drive, controls the engine at all speeds, and starting is effected by a Berger starter.

PROPULSION AND AUXILIARY MACHINERY FOR WHALE CATCHER.

Fig. 122, opposite, shows a model which is being exhibited on the same stand. It shows the propulsion and auxiliary machinery which is being supplied by the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne, to United Whalers, Limited, for installation in the whale catcher Setter IX. The equipment consists of two engines, each of which is capable of developing 1,600 brake horse-power when running at 350 r.p.m. They are connected through electric slip couplings and reduction gearing to a Kamewa variable-pitch propeller, manufactured by Messrs. J. Stone and Company, Limited, Charlton, London. Control can be effected from either the bridge or the engine-room. The couplings have a maximum slip of 3 per cent. at full load and a loading of about 14 kW. The reduction ratio of the gearing is 2 to 1, giving a propeller-shaft speed of 175 r.p.m. Auxiliary power is provided by three 100-kW sets, which consist of National engines coupled to Laurence Scott 220-volt dynamos. Steam is provided at 60 lb. per square inch from a boiler, which is heated by the exhaust gases and has an output of 1,100 lb. per hour, and from an oil-fired boiler with the same capacity.

BRAIDED WIRE-ROPE SLING.

Braided wire-rope slings are among the products exhibited by British Ropes, Limited, Doncaster. One of these slings in use for hoisting a heavy casting is illustrated in Fig. 124, on this page. The chief advantages of these braided slings are their extreme flexibility, their resistance to kinking, and the almost complete absence of any tendency to twist or spin. The method of braiding is the subject of a provisional patent and differs from the usual American practice. The braiding itself consists of eight interlaced multi-strand flexible wire-ropes of small diameter. A number of slings of various sizes are being shown, to demonstrate their flexibility. It has been found in practice that the braided sling greatly reduces any tendency for the load to slip, and, since there is a greater contact area, timber can be slung without sustaining damage. Particularly large slings of this type have been used to lift loads of up to 55 tons.

INDUSTRIAL GAS TURBINE.

The most significant and praiseworthy exhibit at Olympia is undoubtedly the Mark TA industrial gas turbine designed and built by Ruston and Hornsby, Limited, Lincoln. Its presence at the exhibition was particularly opportune since it has provided lighting current during the electricians'

strike, to conform with public-safety requirements. It is shown in position in Fig. 125, on page 368. The normal continuous rating without heat exchanger is 1,260 brake horse-power or 900 kW, giving an efficiency of 15·9 per cent. With a heat exchanger, operating at 75 per cent. effectiveness, the normal continuous rating is reduced to 1,050 brake horse-power at 750 kW, giving an efficiency of 22·5 per cent. The maximum rating (overload) is 1,410 brake horse-power, 1,000 kW, without heat exchanger or 1,200 brake horse-power, 850 kW, with heat exchanger. The normal power-turbine speed is 6,000 r.p.m.

The Mark TA turbine was described on page 321 of our issue of March 13 this year, but since then the makers have published an informative brochure on the turbine which gives some additional facts. For the non-recuperative machine, the pressures and temperatures at various stages are as follow: 61 lb. per square inch and 380 deg. F. at the outlet of the axial compressor; 60 lb. per square inch and 1,340 deg. F. at the inlet to the compressor turbine from the combustion chamber; 24 lb. per square inch and 1,020 deg. F. at the inlet to the power turbine; 14·7 lb. per square inch and 845 deg. F. at the outlet from the power turbine.

A long life of the gas turbine is now assured. The chief advantages of the Ruston machine are its simplicity of construction, ensuring low maintenance charges; freedom from vibration, which reduces foundation and installation charges; low weight—it is said to weigh only one-third of the lightest alternative prime mover; the fact that it is self-contained, requiring only a supply of liquid or gaseous fuel; and the opportunity for utilising the waste heat for producing steam.

Underwater Television Camera.

An improved underwater television camera has been developed by Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, in conjunction with Siebe, Gorman and Company, Limited, Davis-road, Tolworth, Surrey, and is shown on the latter firm's stand. The chief feature is a periscopic lens with remote control. This can be moved to cover a hemispherical field of view, while the camera itself remains stationary. In this way, difficulties due to moving the camera when the weather conditions are bad are overcome. The illustration, Fig. 126, on page 368, shows the prototype undergoing a tank-test. The Perspex hemisphere covering the lens can be seen at the bottom of the casing. As Perspex has the same refractive index as water, there is no distortion, and scratches on the surface are not seen on the monitor screen. The pressure casing has also been redesigned to reduce weight and give a smoother finish.

Exhaust Turbo-Extractor.

A novel device to improve the performance of internal-combustion engines is an exhaust extractor being shown by Wade Engineering, Limited, Gatwick Airport, Horley, Surrey, and illustrated in Fig. 127, on page 368. This device fits on to the exhaust port of the engine and the motive power is the exhaust gas itself. The first rush of the released gases spins the rotors of the extractor, and then, as the pressure falls off, the inertia of the rotors keeps them revolving and they draw out the rest of the exhaust gas. By suitably positioning the extractor, the initial pressure wave will reach it before the engine reaches bottom dead centre, and the presence of the rotors will prevent any return waves from reaching the exhaust port. Thus an even release of exhaust gas is obtained, and consequently improved scavenging and performance. Further, since more exhaust gas will be extracted, the engine will run cooler. All the energy required to drive the extractor comes from the initial pulse of the exhaust gases, and no net power is drawn from the engine. The extractor also acts as a very efficient silencer. It can be used with both four-stroke or two-stroke engines, but is more suited to Diesel engines, where it does not matter if a little of the air drawn in during the overlap period of the valves is taken into the exhaust system. In size it is about equal to the complete exhaust manifold of a 70-h.p. four-stroke oil engine; it would replace the manifold.

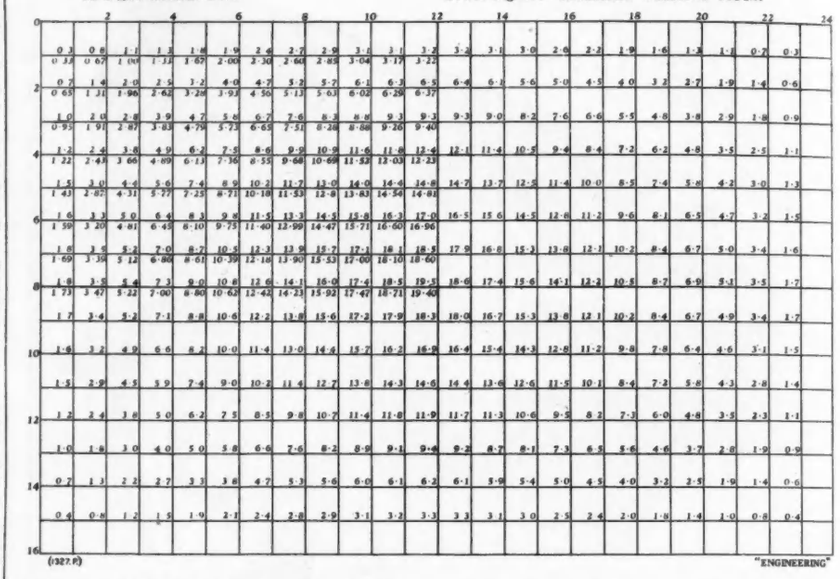
(*To be continued.*)

BENDING OF RECTANGULAR PLATES.

Fig. 9.

Plate Deflections
12·8 Lb. Central Load

Upper Figures = Experimental Values × 0·001 In.
Lower Figures = Relaxation Values × 0·001 In.



THE BENDING OF SIMPLY-SUPPORTED RECTANGULAR PLATES.

By K. R. Peattie, B.Sc., A.M.I.C.E., and G. F. Day, B.Sc. (Eng.).

(*Concluded from page 310.*)

The first test consisted of applying a 12·8-lb. load to the centre point of the plate and measuring the deflections over the whole plate. These measured deflections are shown in comparison with the values obtained by relaxation methods from a 1-in. grid in Fig. 9, herewith. A comparison of the experimentally determined deflections with the calculated values is also given by the deflection contours shown in Fig. 10, opposite. A similar test was made with a 19·2-lb. load applied at point (8, 4); the measured and calculated deflections are shown in Fig. 11, opposite, and the deflection contours for this loading appear in Fig. 12.

Strains were measured in directions parallel to the edges of the plate at the nodes of a 2-in. grid. For a central load of 19 lb., the strains were measured over one quarter of the plate. Because of the small values of the strains towards the corners of the plate, it was not possible to measure these. Comparison of the measured values and those obtained from the relaxation solutions of the stresses in the x and y directions are shown by the stress contours in Figs. 13 and 14, opposite.

It was determined that the load-deflection relationship for a load applied at the point (8, 4) was linear for loads of up to 30 lb. and strain measurements were made round this point, at which a load of 27 lb. was applied. The stress contours for stresses in the x and y directions are shown in Figs. 15 and 16.

The plate was then removed from the frame, reversed and replaced. It was set up in the manner previously described, so that the condition of symmetrical deflections existed for a central-point load. The load-deflection relationships were then determined for a number of points on the plate, and the values of deflections for a 1-lb. load obtained from this series of readings are compared with the same deflections as obtained from the first series, and also those obtained from the relaxation solution, in Table V.

Table V.—*Deflections* (10^{-3} in.) *for* 1-*lb. Central Load.*

Point.	Experimental.		Relaxation.
	2nd Series.	1st Series.	1-in. Grid Values.
(4,4)	0·395	0·377	0·382
(4,8)	0·580	0·523	0·547
(8,4)	0·818	0·743	0·757
(8,8)	1·198	1·072	1·112
(12,4)	1·018	0·978	0·957
(12,8)	1·542	1·463	1·518

The agreement between the measured quantities and those obtained from the relaxation solution of the general equation for the flexure of a flat plate is, in most cases, good. Except for points at the edges of the plate, where the deflections are small, the greatest deviations between the measured and calculated deflections are about 3 to 4 per cent., and these only occur at isolated points. The deviations between the measured and calculated stresses are somewhat higher when expressed as a percentage, but the difficulty of measuring accurately the very small strains developed in the plate is a large contributing factor towards this.

It is seen from Table V that the deflections obtained in the second series of tests show an increase of about 8 to 9 per cent. over those obtained in the first series. The only noticeable experimental difference between the two series of tests was that

Table VI.—Bending Moments (In.-Lb.) for a Central Load P.

Point.	Mx.				My.			
	2-in. Grid.	1-in. Grid.	½-in. Grid.	Series.	2-in. Grid.	1-in. Grid.	½-in. Grid.	Series.
(10,6)	0·1049P	0·1079P	0·1084P	0·1059P	0·1409P	0·1437P	0·1444P	0·1414P
(12,8)	0·3073P	0·3782P	0·4488P	0·2519P	0·3457P	0·4165P	0·4868P	0·2956P

BENDING OF SIMPLY-SUPPORTED RECTANGULAR PLATES.

Fig. 10. *Deflection Contours*
12·8 Lb. Load at Pt. 12·8

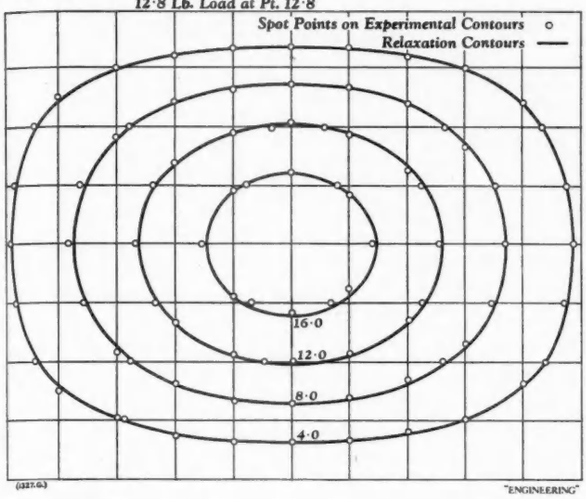


Fig. 12. *Deflection Contours*
19·2 Lb. Load at Pt. 8·4

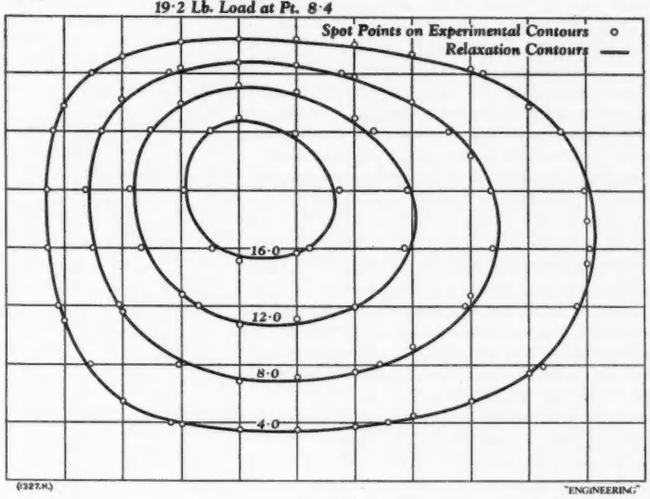


Fig. 11.
Plate Deflections
19·2 Lb. Load at Pt. 8·4
Upper Figures = Experimental Values × 0·001 In. Units
Lower Figures = Relaxation Values × 0·001 In. Units

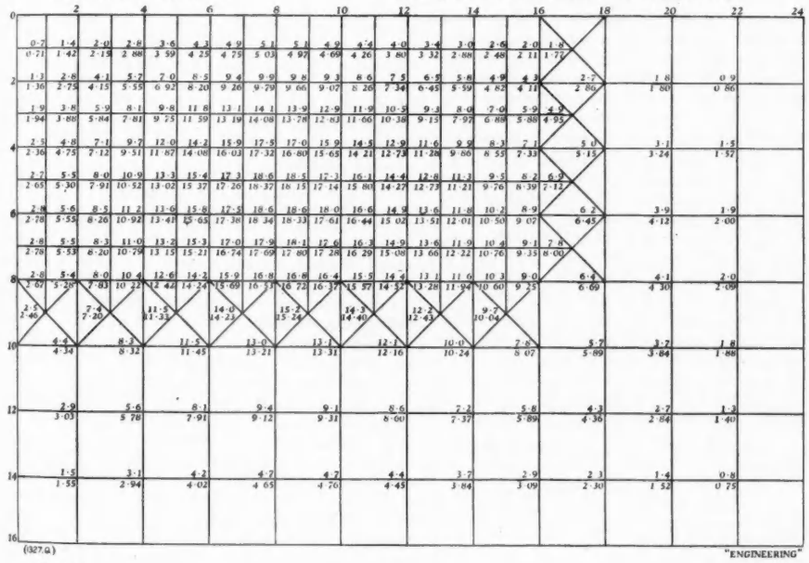


Fig. 15. *Contours of Stress in X Direction*
27 Lb. Load at Pt. 8·4

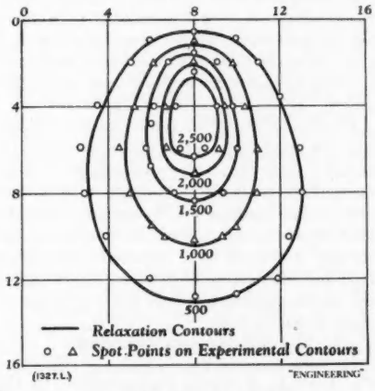


Fig. 16. *Contours of Stress in Y Direction*
27 Lb. Load at Pt. 8·4

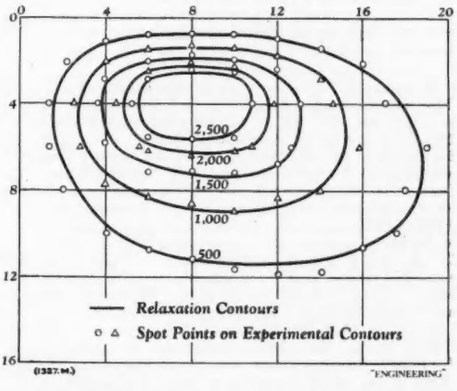


Fig. 13.
Contours of Stress in X Direction
19 Lb. Central Load

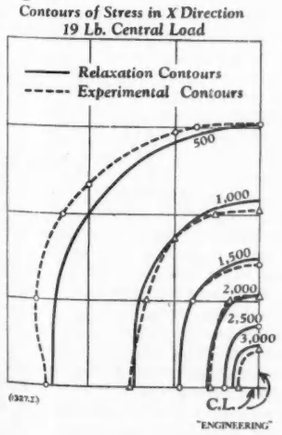
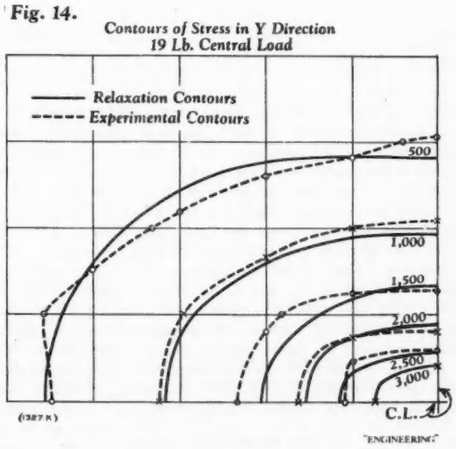


Fig. 14.
Contours of Stress in Y Direction
19 Lb. Central Load



the symmetrical-deflection condition was obtained in the second series, before the lower strips had been driven home as firmly as they were in the first series, and presumably there were slight gaps between the plate and the knife edges which permitted larger deflections in the second series.

The fineness of the grid which should be used in any particular case is a matter of some importance. For the plate size used, it appears that a 2-in. grid would be adequate for most purposes, as the variation in the deflection and bending-moment values resulting from the use of a 1-in. grid is too small to justify the extra labour involved. It may be necessary, however, to employ graded nets close to the points of application of the load if bending moments are to be evaluated to a reasonable degree of accuracy.

The values of deflection in Tables III and IV show that the series solution gives results which are in good agreement with those obtained from the relaxation solution. The largest variation in each case occurs at the point of loading. The bending

moments at two points, (10,6) and (12,8), were evaluated for a load applied at point (12,8) and these results are given in Table VI, on page 358. In each case, 22 terms of the series were evaluated. For point (10,6) the results lie between those of the 2-in. and 1-in. relaxation grids, but for point (12,8) the results are considerably smaller than those obtained by any of the relaxation solutions. It was found that the convergence of the series for this point was extremely slow, and it is also seen from Tables I and II that, as advances are made to progressively finer nets, it is only at this point (12,8), at which the load is applied, that there are large changes in the values of the bending moments. These increases are a result of limitations imposed by the assumptions made in the elementary theory of the bending of plates. If the area over which any given load is applied is progressively decreased, the intensity of pressure on the plate increases to such a value that it can no longer be considered negligible in comparison with the bending stresses. In advancing to progressively finer nets, the load is considered to be acting over a progressively decreasing area; consequently, the bending moment at the point of application of the load will increase with each reduction in net size. These large increases in bending moment are not found at points comparatively close to the load point, e.g., (11,8) and (12,7). Even for the evaluation of the bending moments at point (10,6), the amount of labour involved in the series solution is very large, and it is considered to be impracticable if the bending moments are required at a large number of points.

One limitation to the results obtained is imposed by the condition, inherent in the fundamental theory, that the deflections of the plate shall everywhere be small in comparison with its thickness. This necessitated the use of low values of load, with the result that the maximum bending stresses developed were about 3 tons per square inch and the agreement between the measured and calculated quantities is only valid over this limited range of load values.

INDUSTRIAL STAFF PHOTOGRAPHERS' CONFERENCE.—The Institute of British Photographers, 49, Gordon-square, London, W.C.1, are arranging to hold a one-day conference for photographers of the staffs of industrial establishments, at Caxton Hall, Westminster, London, S.W.1, on Monday, November 9, 1953. Tickets, price one guinea, including refreshments, may be obtained from the Institute.

NARROW-GAUGE INDUSTRIAL DIESEL LOCOMOTIVE.—The Hunslet Engine Co., Ltd., Jack-lane, Leeds, 10, announce the addition of a four-wheel narrow-gauge Diesel locomotive to their present range. It is built for gauges of 600 mm. and upwards and, with a total weight of 5 tons, has a maximum axle-load of 2·6 tons. Curves of 25 ft. radius can be traversed and the lightest suitable rail is 15 lb. per yard. Powered by a Perkins P4 engine, it develops 35 b.h.p. at 1,700 r.p.m.: a two-speed gearbox gives track speeds of 3·85 and 7·7 m.p.h. Loads up to 160 tons can be started and hauled in bottom gear. The wheelbase is 3 ft. and the length over buffer-beams is 8 ft. 11 in. The distributors are Robert Hudson, Ltd., Meadow-lane, Leeds, 11.

SYMPOSIUM ON OIL FILTRATION IN MODERN INDUSTRY.—Arrangements are being made by the Department of Engineering of the University of California, Los Angeles, in co-operation with the American Society of Lubrication Engineers, to hold a symposium for the discussion of the whole range of problems relating to oil filtration in modern engines and hydraulic power mechanisms. This symposium will take place in the University, on Thursday and Friday, February 11 and 12, 1954. A series of questionnaires dealing, respectively, with methods of filtration: full flow or by-pass; filter media; oil; engine wear; and hydraulic power oils, has been prepared in connection with the meeting for completion by interested persons. Speakers and subjects for discussion will be based mainly upon the answers received to these inquiries. Copies of the questionnaires and additional information may be obtained from the Engineering Extension, University of California, 3076 Engineering Building, Los Angeles 24, California, U.S.A.

ROCKET EXPLORATION OF THE UPPER ATMOSPHERE.

By J. HUMPHRIES, B.Sc.(Eng.), A.M.I.Mech.E., A.F.R.Ae.S.

THE Conference on Rocket Exploration of the Upper Atmosphere, held in Oxford from August 24 to 26, was sponsored by the Gassiot Committee of the Royal Society. The tremendous headway made by the United States since 1946 was obvious from the fact that 19 of the 24 major papers were by Americans. Since the first flight of a modified V.2 rocket on April 16, 1946, about 30 tons of upper-atmosphere research equipment have been carried to heights up to 242½ miles.

The rockets that have been used throughout most of the programme are the V.2, Aerobee and Viking. These vehicles were described by Mr. Milton W. Rosen and Mr. Richard B. Snodgrass in their paper "The High Altitude Sounding Rocket," and by Dr. Charles F. Green in "Utilization of the V.2 (A-4) Rocket in Upper Atmosphere Research." The V.2, although originally a military missile, was used extensively at the beginning of the programme since it was readily available and could carry a heavy payload; the designed warhead weighed 2,220 lb., but the instrument loads exceeded this by up to 1,036 lb. The mean altitude reached was 60 miles, with a maximum of 133 miles. It was realised early in the programme that the limited number of V.2's (about 100) would be insufficient, and further vehicles were needed. The result was the Aerobee. This was extremely simple, having no moving surfaces and relying on arrow stability; thus it had to be fired from a launching tower by means of a booster rocket. Its empty weight was only some 200 lb., and it was capable of taking a 150-lb. payload to a height of about 75 miles.

More recently the Viking had been developed, in recognition of the need to carry equipment to extreme altitudes for certain experiments. The vehicle was in some respects similar to V.2, but since it was intended for vertical flight only, it was much less complex and was smaller, weighing only 11,000 lb. fully loaded. It was intended finally to carry a 1,000-lb. payload to an altitude of 190 miles, but at present it was in the stage of taking a 500-lb. payload to 136 miles—the present altitude record for a single-stage rocket. The altitude performances for these three rockets are summarised in the accompanying Table (according to Rosen and Snodgrass). A normal flight was arbitrarily taken

Altitude Performance of V.2, Aerobee and Viking Rockets.

—	V.2.	Aerobee.	Viking.
Total fired (to January 1, 1953)	62	81	9
Average altitude (miles) ..	60	47	73
Maximum altitude (miles) ..	133	80	136
Number of normal flights ..	42	70	4
Average altitude—normal flights (miles)	82	54	121

as one in which the power plant operated for practically the full duration and there was no major failure within the rocket. On this basis, more than two-thirds of the V.2 firings were normal—a remarkable achievement considering that many of them had been in store for years; this proportion was, in fact, higher than that achieved by the Germans. But most striking was the very high number of successes (87 per cent.) achieved by the simple Aerobee. These reliability figures had been improved still further by the firing of 25 more Aerobees during the past two months without a single failure. The low number of normal flights of the Viking could be explained by its developmental nature, but even so, the average altitude reached was well above that of the V.2, and considerable data had been obtained from all flights.

LAUNCHING A ROCKET FROM A BALLOON.

Unfortunately, such vehicles are very expensive; the Aerobee costs 25,000 dols. and the Viking 400,000 dols., so that there is a great need for a low-cost method of reaching the upper atmosphere. Such a method was discussed by Dr. J. A. Van Allen in his paper "The Inexpensive Attainment of High Altitudes with Balloon-Launched Rockets." The great drawback to launching small rockets at ground level, he said, was that atmospheric drag very much reduced the summit altitude below that which could be expected in vacuo. A simple scheme had been developed for lifting a small instrumented solid-propellant rocket, about 9 ft. in length by 6½ in. diameter, to some 50,000 ft., by means of a balloon, and then firing the rocket in a near-vertical direction. In this way the aerodynamic resistance of the lower atmosphere was eliminated. During this summer payloads of 30 lb. had reached over 60 miles altitude over Baffin Bay. The main object of these flights had been the study of cosmic rays near the geomagnetic pole.

The cost of such a balloon and rocket assembly was about 1,200 dols., and it was suggested that the technique would make economically feasible the conduct of a variety of high-altitude experiments on a synoptic basis. One of the chief limitations of rocket methods to date had been the fact that it had been possible to make only a comparatively few firings per year from a limited number of localities. For many purposes it was important to be able to launch from any locality, or to launch several rockets with only small time intervals, or to fire a number of rockets from various places at the same time. It was hoped that this new technique would enable much of this work to be initiated. There was great interest in the method among British workers, although the drift of the balloon during its flight (duration about one hour) introduced an extra element of danger which might not be acceptable in crowded areas such as Britain. However, Dr. Fred Singer of the Naval Research Laboratory has suggested the use of aircraft instead of balloons. This method would have the added advantages that the exact point of firing would be known and that the time could be controlled with great exactitude.

ARTIFICIAL SATELLITES.

One other major drawback of the rocket for high-altitude research is its short time of stay in the region of interest—never more than a few minutes. Important lines of research needing extended times for recording data are the study of solar and stellar radiation and cosmic rays. One method for obtaining periods of days for recording data would be to use instrument-carrying artificial satellites. These were discussed by Dr. Singer in two papers entitled "Use of Satellite Stations for Studying Atmospheric Magnetism" and "Use of Satellite Stations for Cosmic Ray Studies." Although the cost of such a project would be extremely high it might be an economic proposition in view of the expense involved in launching a large enough number of conventional high-altitude research rockets to obtain the same total recording time. Attractive though this scheme was to the upper-atmosphere physicists, general opinion was that rocket techniques were not sufficiently far advanced to warrant the enormous outlay of money required, and that there was still much work to be done with conventional rockets.

Two of the largest agencies engaged on upper-atmosphere rocket research are those of the Air Force Air Materiel Command and the Naval Research Laboratory, both of the U.S.A. Dr. M. O'Day reviewed the Air Force work in his paper "Upper Air Research by Use of Rockets." Their programme began, he said, in 1946, when it was decided to do most of this research by contract, contrary to the Navy's method, and as funds became available the various projects were passed on to universities and other non-profit-making organisations. One restriction in laying out the programme was that work being carried out by any other agency could not be duplicated. The Air Force Cambridge Research Center had the primary responsibility for the implementation of the programme, which was divided into two parts, the first dealing with techniques, especially the stabilising of the vehicles, and the second with the measurement of the various upper-air parameters as functions of altitude. Some experiments, such as the obtaining of solar spectograms, were impossible unless the rocket could be stabilised, and much effort had gone into achieving this. The most satisfactory

solution was the "sunseeker," which consisted of an arm extending out from the rocket, which kept itself pointed at the sun by means of a photocell. Equipment could thus be orientated to ± 3 minutes of arc regardless of the movement of the rocket. They had also developed the technique of photographing the landscape and horizon from the rocket, and from these photographs determining its attitude. The method was simple to apply and quite useful where it was not essential to maintain orientation of equipment.

The recovery of equipment had featured very largely in their programme. A rocket allowed to come down in one piece buried itself in the ground and any equipment being carried was destroyed. It was possible to spoil the aerodynamic shape of a missile by breaking it in two when it was near the top of its trajectory, and thus allow the two parts to come to earth comparatively slowly. If the equipment were properly placed and suitably armoured, the records could be recovered. Another method consisted of ejecting the warhead and bringing it down by parachute. Early tests on V.2's were unsuccessful, the parachute "squidding," thus acting like the tail of a kite and stabilising the warhead so that it hit the ground at a high supersonic velocity. The first time this happened the warhead was buried 25 ft. deep, but since some of the data had been recorded on magnetic tape it was decided to dig it out by means of a power shovel. Despite the fact that the magnetic tape had been torn in small pieces, it was possible to obtain all the data from it. More success was achieved when the parachute technique was applied to the Aerobee; equipment could be recovered almost without damage from a height of 70 miles.

Measurements of the Atmosphere.

The purely scientific side of the programme came under three main headings; molecular dynamics, ionospheric investigations, and radiation. Some of the molecular dynamics topics were investigation of the composition of the atmosphere as a function of height, upper air winds, density of meteoric dust and ambient temperature and pressure. Several methods had been developed by the University of Michigan for the measurement of density, pressure and temperature. In three of these methods the idea was to measure the Mach number and velocity of the rocket, from which data the velocity of sound and temperature could be directly calculated.

In one method the pressures at the tip and at four points on the side of a cone were measured; from these the Mach number could be calculated. In the second method the angle of the shock wave formed by a wedge at the front of the rocket was to have been measured by shadowgraph equipment; the Mach number was known as a function of shock-wave angle. In a third method the angle of a shock wave formed by a cone was measured by an array of moving probes containing pressure gauges, these gauges giving signals on passing through the shock wave. Temperature measurements of useful precision were obtained only from one flight using the moving-probe technique. It was decided that the major cause of failure was the complexity of the equipment, and a simpler method was developed. This consisted of a nylon sphere 4 ft. in diameter, which contained a Doppler transmitter and antenna. The collapsed sphere was carried up by an Aerobee rocket and ejected by means of stretched rubber bands at the top of the trajectory. A small air bottle inside the sphere then opened and expanded the sphere. By ground tracking, the trajectory and velocities were obtained, and thus, with a knowledge of the drag coefficients of the sphere, the density and temperature variation with height could be calculated. Three such spheres had been flown so far, all with partial success. In the first two flights, leaks had developed in the spheres but useful data for the higher parts of the flight, before the spheres started to collapse, had been obtained. On the third test the central ground recording failed during the most interesting part of the trajectory. It was intended to extend this work to include the measurement of upper-atmosphere winds.

Perhaps one of the most interesting experiments undertaken to date was the measurement of meteor impacts by mounting crystal microphones on the inside of the skin of the rocket. The microphones were connected to amplifiers tuned in the region 30 to 60 kc. The microphones were also sensitive in this region, and thus a meteor particle would give a sharp pulse. In one flight, 66 pips of a random nature were detected at a rate of about one every 2·2 seconds per sq. ft. For work of this type, this agreed reasonably with the calculated figure of one every 0·9 second per sq. ft. Ionospheric investigations included the direct measurement of electron density, the study of cross modulation and the study of the propagation of pulses over long distances. Dr. O'Day considered that the experiments dealing with radiation, either coming directly from the sun or from processes in the upper atmosphere, were the most important being performed with rocket-borne equipment. The work covered the study of sky brightness and the measurement of the solar constant. The sky brightness work was started originally as a study of scattered light and its possible effect on automatic celestial navigation of missiles in the day-time. It was soon discovered that there was a departure from the normal scattering law at high altitude. Instead of the scattered light gradually decreasing, it apparently remained constant at altitudes exceeding 20 miles. It was considered that this might be due to the excitation of the atoms and molecules by resonance radiation from the sun. This was an important discovery and the work was continuing.

Velocity of Sound Measured to Determine Temperature.

The Naval Research Laboratory, U.S.A., and other agencies have also been investigating similar problems. Besides the determination of the physical properties of the atmosphere, much effort has gone into cosmic-ray studies, the measurement of the distribution of ozone, the study of the sun's ultra-violet spectrum, upper-air wind determination, radio propagation and many other items. The rocket is an exceptionally powerful instrument in cosmic-ray studies since it is the only way in which primaries may be directly studied, and much progress has been made since 1946. A great feature of all this work is the manner in which different agencies tackle the problem of obtaining the values of a certain parameter by entirely different methods. Four methods of obtaining temperatures have already been mentioned; a further method was described by Dr. M. Ference, of the Signal Corps Engineering Laboratories, U.S.A., in his paper "Temperature in the Earth's Upper Atmosphere." The mean temperature of a layer of atmosphere was determined by measurement of the average velocity of sound through the layer. The sources of sound were 4-lb. grenades, seven of which were ejected at predetermined heights from an Aerobee rocket. Three ballistic cameras on the ground recorded the flashes, from which the co-ordinates of the explosions could be deduced. The exact times of the explosions were obtained from photocells in the rocket and microphones on the ground recorded the sound. From these data, both temperatures and wind velocities in the various layers could be calculated. These experiments were carried out over White Sands Proving Ground in New Mexico, where the wind directions were found to be easterly in summer and westerly in autumn and winter. The speeds appeared to reach a maximum at 55 km., the highest measured being 102 m. per second.

The impression gained at the Conference was that, considering the technical problems of getting equipment aloft, making it work under exceptionally difficult circumstances, and the complexity of the data so obtained, the amount of knowledge amassed in seven years is highly creditable. However, it has involved a very large number of workers and an outlay of millions of pounds. Such work could not progress without Government backing. The basic physical properties of the atmosphere, namely, pressure, density and temperature, are moderately well known at certain latitudes up to 110 km., but even here there is room for some doubt. The more abstruse properties and the properties of solar and cosmic radiation at high altitudes have only just been touched upon, and many more years of upper-atmosphere research by rocket will be needed before some of the problems are solved.

PROJECTED TUNNEL UNDER THE CLYDE.

Without in any way committing himself, the Minister of Transport, Mr. A. T. Lennox-Boyd, succeeded on September 2 in conveying the impression that the construction of a tunnel under the River Clyde would rank comparatively high in the matter of priorities for permission to carry out such schemes. Addressing a Press conference after he had received a deputation in the City Chambers, Glasgow, the Minister said that a "very strong case indeed" for proceeding with the projected Whiteinch-Linthouse tunnel had been put forward. Two significant remarks he made were that he hoped it might be possible to give some encouragement to the project to carry it a stage further, and that there was no question of the Dartford-Purfleet tunnel under the Thames being preferred to the Clyde scheme.

He said he was concerned with transport problems in Scotland as a whole, and with this "highly important artery," the Whiteinch-Linthouse tunnel, in particular. The problem of cross-river communication in Glasgow had been discussed, and there was no doubt whatever that the tunnel was a highly desirable project. Technical examination had shown that it was a perfectly feasible project on the line that the city's experts had proposed. The Minister pointed out that a large amount of public money (800,000*l.*) had already been spent on the Thames tunnel and that there was always bound to be a bias in favour of completing work on which a great deal had been spent and which was entailing a large annual expenditure to prevent its being wasted altogether. Each year, however, had to be judged as it came and there was a very strong case for the Whiteinch-Linthouse tunnel. The Dartford-Purfleet tunnel would cost a further 9,000,000*l.* to complete, and was costing 12,000*l.* a year to keep it drained.

One of the problems of prime importance so far as the various cross-river projects in the United Kingdom were concerned at present was the tunnel-driving shields used to protect the tunnellers. These shields cost 100,000*l.* each, and there were only four of them in the country. Two were in place at the Dartford-Purfleet tunnel, one was on the bank of the Thames, and one was under construction. The point of discussion was how the two shields not yet in use could be best employed in the interest of the United Kingdom as a whole. Should they be moved to the north-east of England, where there was a demand for a tunnel under the Tyne, or to the Clyde? The two shields in position in the Thames tunnel would suffice for the job, but possibly the use of four shields would finish the work a year sooner. There was no suggestion, however, that the Thames tunnel must be completed before anything else could be started.

The deputation which met the Minister, who was accompanied by Commander T. D. Galbraith, Under-Secretary of State for Scotland, was headed by the Lord Provost of Glasgow (Mr. T. A. Kerr) and other representatives of Glasgow Corporation. Councillor Thomas Kay, convener of the Highways Committee of Glasgow Corporation, said that the projected Clyde tunnel was the key to the whole road system in Glasgow and to the city's Development Plan. Powers to build the tunnel had been obtained in 1948, but authority had not yet been given to proceed, except for the taking of borings. Sir Robert Inglis, in his British Transport Commission Report, had stated that the tunnel was essential and gave it first priority.

German Autobahnen.—A 9-km. extension to the Kassel-Göttingen Autobahn, between Noerton and Northeim-West, has recently been opened to traffic. This is the first new stretch of autobahn to be completed since the end of the war.

50-Ton Press: Erratum.—In the 17th line of the description of the 50-ton press manufactured by Finney Presses, Limited, Birmingham, 1, published in the third column of page 291 of our issue of September 4, the word "half" appears, whereas the word "twice" is intended. The error is regretted.

THE SHEPCOTE-LANE PLANT OF FIRTH-VICKERS STAINLESS STEELS, LTD.

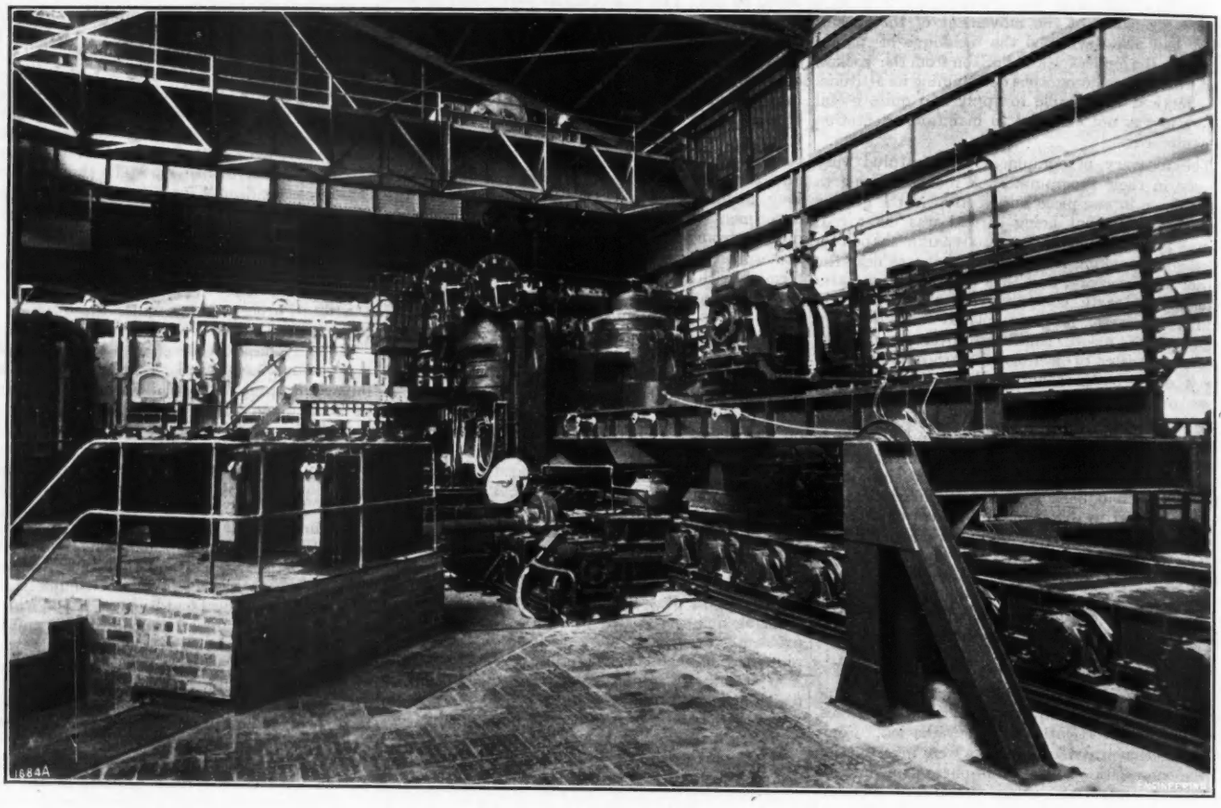


FIG. 5. ROUGHING MILL FROM OUTGOING SIDE.

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(*Concluded from page* 333.)

IN the previous instalment of this article, the main particulars were given of the hot-mill line, consisting of the two-high roughing mill and a four-high finishing mill. Illustrations of these mills are given herewith in Figs. 5 and 6, and in Figs. 7 to 10, on Plate XXIV. As we have mentioned, the whole of the contract for the hot mills was placed with the Davy and United Engineering Company, Limited, of Park Iron Works, Sheffield. Fig. 5 is a general view of the roughing mill, seen from the outgoing side; the slab reheating furnace is shown in the background. Fig. 6 shows the approach table of the roughing mill, the furnace being on the right. In the foreground of this illustration is the reverse take-off table, used when the mill is rolling plates.

Fig. 7, on Plate XXIV, shows the overhead-type pusher on the outgoing side of the roughing mill, which ensures a positive entry of the slab between the rolls, during the initial process of breaking-down. On either side are the hydraulically-operated pushers which centre the slab on the roller table, and in the foreground is the vertical edging mill. Both the ingoing and outgoing tables of the roughing mill are provided with hydraulic turntables on which the slabs are rotated prior to broadsiding; one of these is shown in action in Fig. 8, on Plate XXIV, which is a view of the ingoing side. Fig. 9, on the same plate, shows the vertical edging mill, which has rolls 24 in. in diameter, electrically controllable to give an opening ranging in width from 12 in. to 6 ft. This illustration also provides a good view of one of the overhead pushers. The remaining illustration on Plate XXIV, namely, Fig. 10, shows the 2,800-h.p. driving motor of the roughing mill; as previously mentioned, this motor was constructed by the British Thomson-Houston Company, Limited.

FIG. 6. CONTINUOUS PUSHER-TYPE FURNACE AND ROUGHING-MILL APPROACH TABLE.

Fig. 11, on Plate XXV, shows the hot finishing mill, in which the "breakdowns" from the roughing mill are reduced, without further heating, to strips between 50 ft. and 60 ft. long. This operation is usually completed in seven passes through the mill. The hot strips then pass through the electrically-driven down-cut shear shown in Fig. 12, on Plate XXV, in which the leading and trailing ends are cropped for welding before entering the three-roll up-coiler in the foreground of the same illustration. The coils are discharged on to the raised platform, from which they are taken by power trucks to the coil storage bay. Between the shear and the up-coiler is a roller table, operating at right angles to the line. This is for handling "moulds," i.e., short lengths of broken-down slab which are required for the production of hand-rolled sheets. These sheets are not made in the Shepcote-lane works, but in another plant belonging to the Firth-Vickers organisation. The moulds are rolled down in the roughing and hot finishing mills to a thickness of $\frac{3}{8}$ in. and widths up to 41$\frac{1}{2}$ in., and are cut into lengths of 2 ft. to 5 ft., as required, in the shear shown in Fig. 12, which can make up to 20 such cuts a minute. A semi-automatic clutch enables single cuts to be made, if necessary. Quick-lift stoppers arrest the mould strip under the shear, where it is held by pneumatic clamps during the cut. As the mould

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(*For Description, see Page 362.*)

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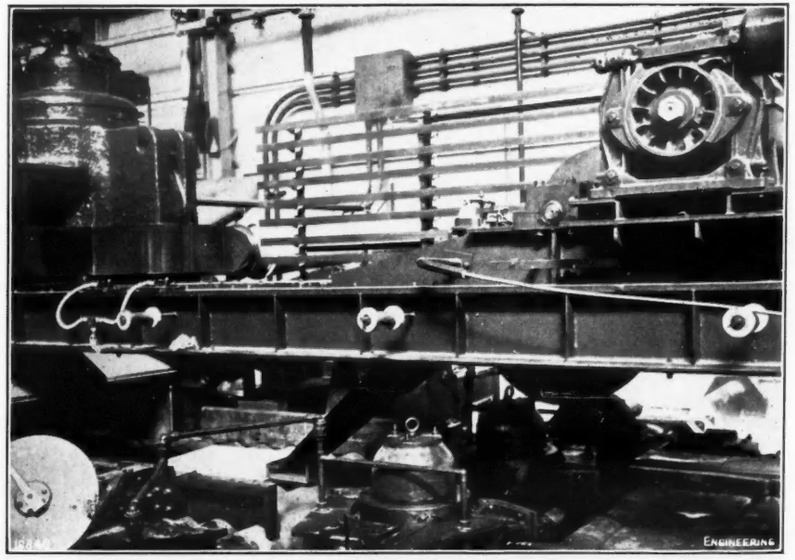

FIG. 7. OVERHEAD-TYPE SLAB PUSHER.

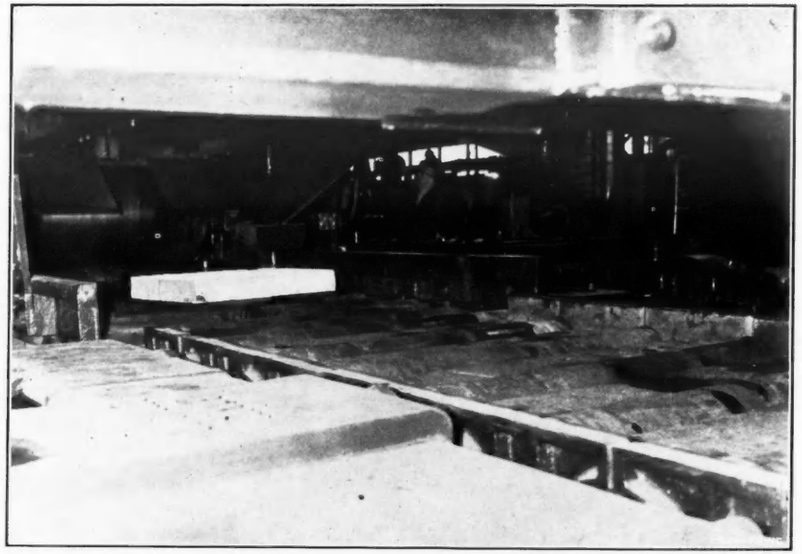

FIG. 8. INGOING SIDE OF ROUGHING MILL: HYDRAULIC TURNTABLE.

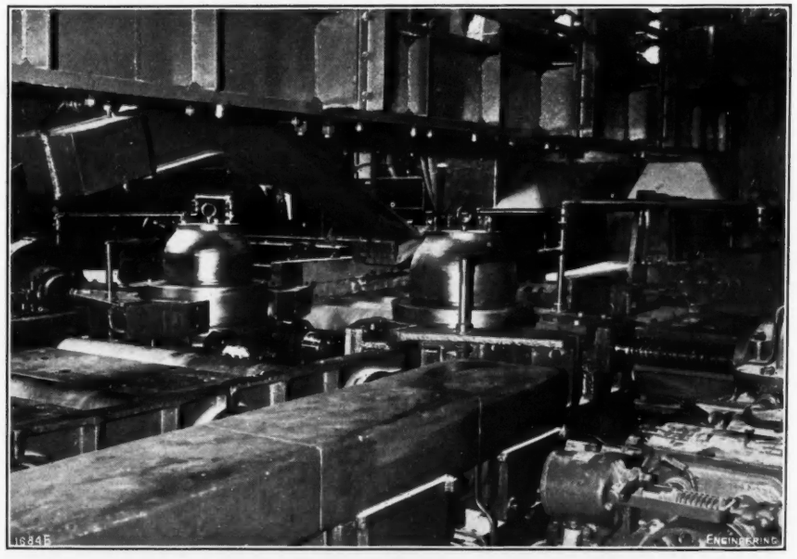

FIG. 9. VERTICAL EDGING MILL.

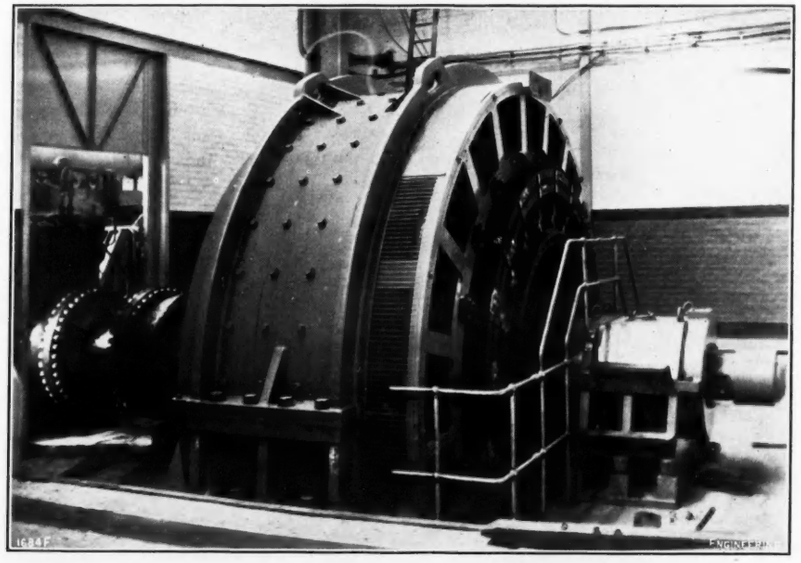

FIG. 10. 2,800-H.P. ROUGHING-MILL MOTOR.

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(*For Description, see Page* 362.)

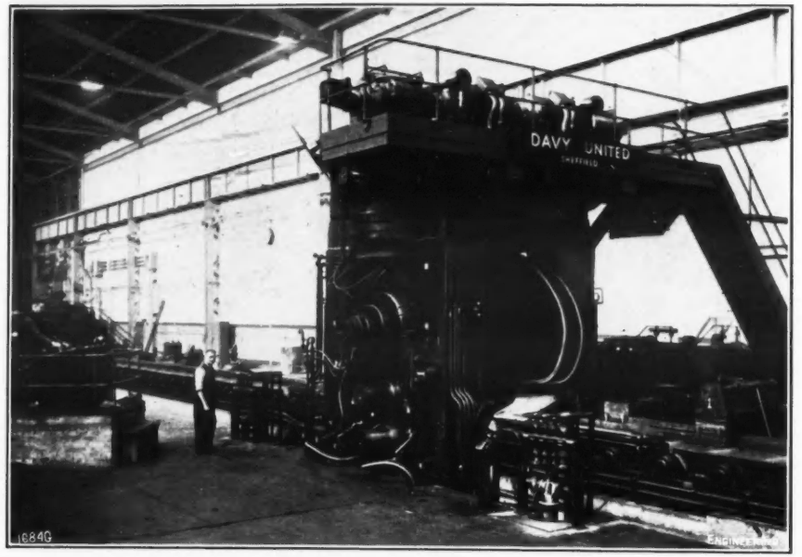

FIG. 11. HOT FINISHING MILL.

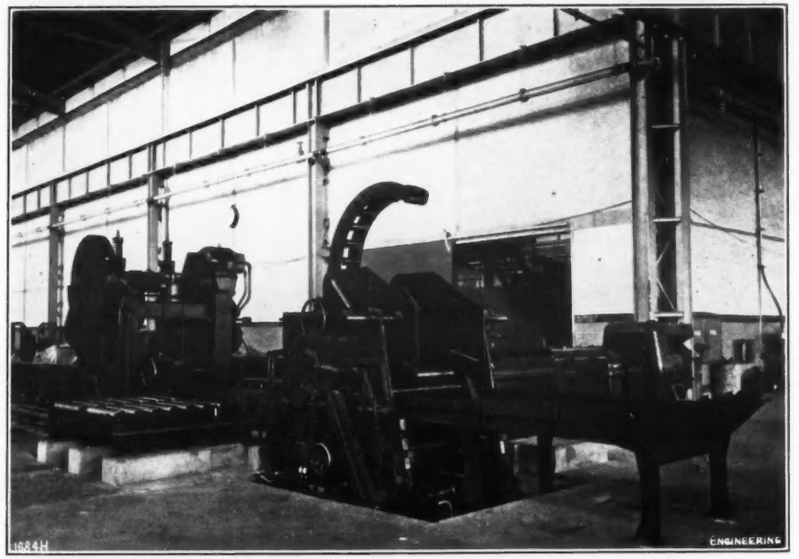

FIG. 12. DOWN-CUT SHEAR AND THREE-ROLL UP-COILER AT END OF HOT MILL LINE.

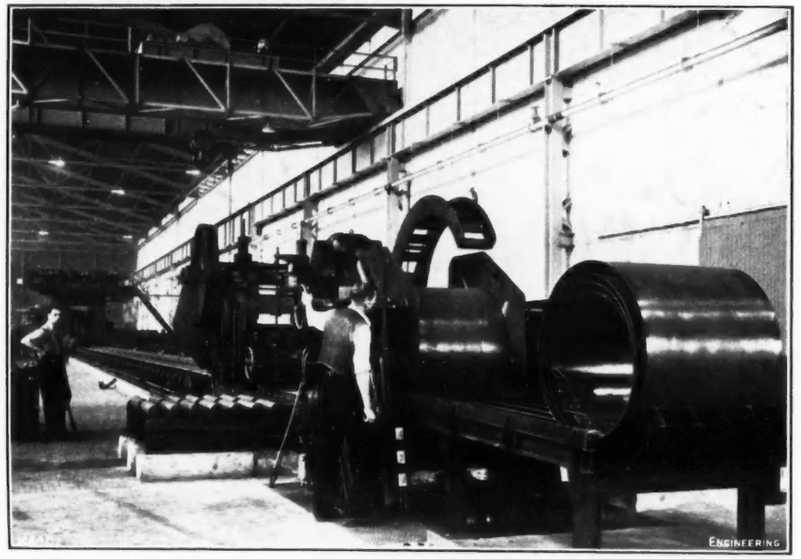

FIG. 13. UP-COILER IN ACTION.

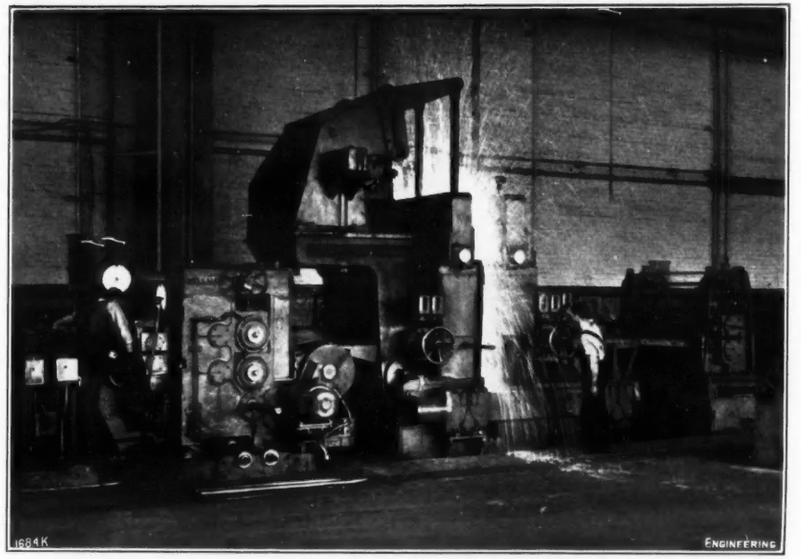

FIG. 14. A.I. ELECTRIC WELDER IN OPERATION.

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SHEPCOTE-LANE STAINLESS-STEEL MILL.

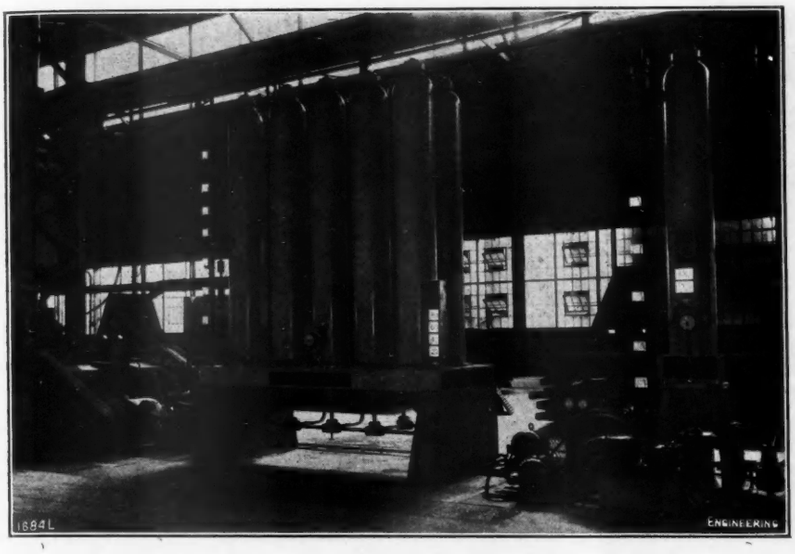

FIG. 15. AIR-HYDRAULIC ACCUMULATORS IN HOT-MILL BAY.

leaves the shear, it comes up against a stop (which can be retracted when strip is being fed to the up-coiler) and is then moved sideways on to the roller table for transfer to the hand mills.

The up-coiler, shown in action in Fig. 13, on Plate XXV, can handle strip up to 0·2 in. thick and 41½ in. wide at coiling speeds up to 200 ft. a minute. The completed coils are usually 30 in. inside diameter and are tightly wrapped except for the last lap, which, by means of a cam-operated gear, is left about 3 in. slack to facilitate subsequent handling. The drive to the up-coiler is by an electric motor through two reduction gears, and is operated semi-automatically from the same control desk as the shear. Hydraulic kick-off mechanism removes the completed coil from the up-coiler on to the sloping platform on the outgoing side.

While 50 ft. to 60 ft. is the greatest length of strip that can be produced in the hot finishing line because of the temperature limitations in producing straight lengths in a reversing mill, much greater lengths are necessary to ensure economic operation in the subsequent cold-rolling process. It is necessary, therefore, to butt-weld several coils together to give the desired coil weight of between 3 tons and 5 tons for efficient cold-rolling. This is done in the coil build-up line, where the hot-rolled coils are accurately matched, the edges trimmed, and short service strips welded on to the ends for handling. The use of these service strips, which are subsequently cut off and re-used, avoids the waste of the finished strip which would occur otherwise. Each hot-rolled coil is uncoiled, passed through a roller leveller and welded to the end of the preceding coil. The strip is then passed through a softening furnace—constructed, like the slab-heating furnace, by Priest Furnaces, Limited, of Middlesbrough—and on through an air-blast cooling chamber into a sodium-hydride descaling tank and thence into a water quenching tank. From this tank it passes through an acid bath, a hot-water wash and a hot-air drying chamber, after which it is separated from the preceding length, re-coiled in an up-coiler, and sent to the cold-rolling line.

The butt-welding machine used has been specially designed by Messrs. A. I. Electric Welding Machines, Limited, Inverness, and is shown in Fig. 14, on Plate XXV. It is adjustable to suit a wide range of strip widths and thicknesses, and is provided with the makers' air-oil intensifier system, whereby the high clamping pressure required can be obtained from an air supply at a pressure of only 80 lb. per square inch.

The two main transformers are housed in the base of the machine. At the top of the frame is the gap-gauge mechanism which lowers and retracts the gap gauge, and which also incorporates stripping blades to clean the welding dies before each weld is made. These blades operate on the downward stroke and are then retracted. A separate stripper unit removes the flash left by the upsetting action in welding, and does this both above and below the weld in one operation. The entire control of the welding machine is by push-buttons from one position, the various stages being interlocked so that a full clamping pressure is applied before welding begins. The interlocking system extends to the control of the feed pinch-rolls.

Fig. 15, on this page, shows the installation of air-hydraulic accumulators in the hot-mill bay. On the right of this illustration is the hydraulic service to the roll balances of both mills, and on the left is the system which serves all the mill auxiliaries. Both services operate at a pressure of 1,500 lb. per square inch.

The four-high cold-rolling mill supplied by W. H. A. Robertson and Company, Limited, Lynton Works, Bedford, and shown in Fig. 20, on Plate XXVI, is a reversing machine with work rolls 17 in. in diameter and 50 in. face width, and support rolls 49 in. in diameter and 50 in. wide. The 1,500-h.p. motor which drives it was supplied by the English Electric Company, Limited, and runs at 500 r.p.m. for a rolling speed of 400 ft. per minute, or 1,000 r.p.m. for a rolling speed of 800 ft. per minute. The coiling and uncoiling equipment in this line can deal with coils up to 5 tons in weight. On the ingoing side, this equipment comprises a hydraulically-operated cradle to transport the coils to the cone decoiler, which has electrically-operated adjustable heads; a flattener and feeding machine; a drum-type coiler; and a guide table. The flattener has four bending rolls, 6 in. in diameter, and two 6-in. feed rolls. The upper feed roll and the bending rolls can be lifted by hydraulic cylinders. The drive is by a 50-h.p. electric motor, which can be run at either 480 or 1,200 r.p.m. The coiler has a solid drum, 26 in. in diameter, driven by a 600-h.p. motor at 500 or 1,000 r.p.m. An air-operated pad holds the end of the strip as it leaves the mill rolls. The drum is hydraulically released and is lifted out by slings from an overhead crane. The guide table is fitted with an air-operated wiper press, air-hydraulic feed-in mechanism, a Taylor, Taylor and Hobson Electrolimit gauge, and roll wipers.

The equipment on the outgoing side comprises a guide table with hydraulically-operated side guides and feed mechanism, a coiler similar to that on the ingoing side, and a three-roll up-coiler with 6-in. rolls. This coiler is driven by an 80-h.p. motor, running at 1,000 to 1,200 r.p.m., and is fitted with feed rolls and an automatic "kick-off." The coilers are designed to deal with tension loads in the strip up to 33,000 lb. The reason for providing a coiler on the outgoing side is to allow the mill to be used, if desired, for uni-directional rolling of thick strip.

The second cold-rolling mill is of the Sendzimir "cluster" type and, as previously mentioned, was constructed by the Waterbury Farrel Foundry and Machine Company, of Waterbury, Connecticut, U.S.A. It is illustrated in Fig. 21, on Plate XXVI. and has two working rolls 2½ in. in diameter, backed up by four 4-in. intermediate rolls and, outside of these, six more intermediate rolls, 6¾ in. in diameter. Outside of these again are eight sets of heavy-duty roller bearings. The only rolls which are driven are four of the six in the outer ring of intermediate rolls. The maximum speed of rolling is 400 ft. per minute. The mill motor is of 600 h.p. Solid-drum coilers are provided for this mill, as for the other cold mill, but in this case they are designed for tensions up to 65,000 lb.

The two cold-rolling mills are served by a common rewinding line for uncoiling the strip off the solid drums for the final softening and descaling. During this process, the service strips on the ends of the rolled strips are cut off and recoiled for further use. Included in this line is a slitting machine for trimming the strips to special widths. An illustration of the recoiling and slitting line, viewed from the exit end, is given in Fig. 23, on page 365. This part of the equipment was supplied by the Wellman Smith Owen Engineering Corporation, Limited, London, S.W.1.

After rewinding, the coils are passed to another softening and descaling line, in which a second electrolytic acid bath is provided in place of the sodium-hydride bath in the first descaling line. They are then coiled on drum coilers and interleaved with paper before being transported to the dispatching warehouse. Four views of the hot descaling line are given in Figs. 16 to 18, on page 364, and in Fig. 19, Plate XXVI. Fig. 16 shows the looper at the ingoing end of the line; Fig. 17, the welder in the foreground, with the looper behind it; Fig. 18 is a general view of the line; and Fig. 19 illustrates its outgoing end. It should be mentioned that, in addition to this equipment, the Wellman Smith Owen Corporation were responsible for the design of the coil build-up and edge-trimming line, and also supplied the two descaling lines and a strip-grinding line; but, in the interest of continuity in describing the processes carried out in the Shepcote-lane plant as a whole, many details of individual items were not inserted where they properly belonged. Some of these details are given below.

HOT-MILL DRIVE.

It was mentioned earlier, for instance, that the British Thomson-Houston Company, Limited, Rugby, had supplied the main motors for driving the roughing and hot finishing mills. These motors, one of which is illustrated in Fig. 10, Plate XXIV, are of the forced-ventilated compensated type, those on the roughing mill having an output of 2,800 h.p. at 30 to 60 r.p.m. and those on the finishing mill the same output at 65 to 130 r.p.m. They are designed however, for peaks of two and a half times and a cut-out of three times the full load torque. The armature of the roughing mill motor is 12 ft. in diameter and weighs over 60 tons. As simultaneous operation of the two mills is not required at present both mills are supplied from a single flywheel motor-generator, which consists of a 2,800-h.p. 11-kV slip-ring induction motor, two 1,200-kW direct-current dynamos and a flywheel with a stored energy of 80,000 h.p. seconds. The motor operates in conjunction with a liquid starter, automatic slip regulator and the flywheel to relieve the supply at peak loads, while the generators are connected in parallel with cross-compounding to ensure good load sharing. Control is effected from desks mounted in convenient positions adjacent to the mill stands, the Ward Leonard system being used, and Amplidyne exciters are provided to assist rapid acceleration and reversal. Both motor-generator sets and motors are installed in a separate room, which is ventilated with clean filtered air. It also contains

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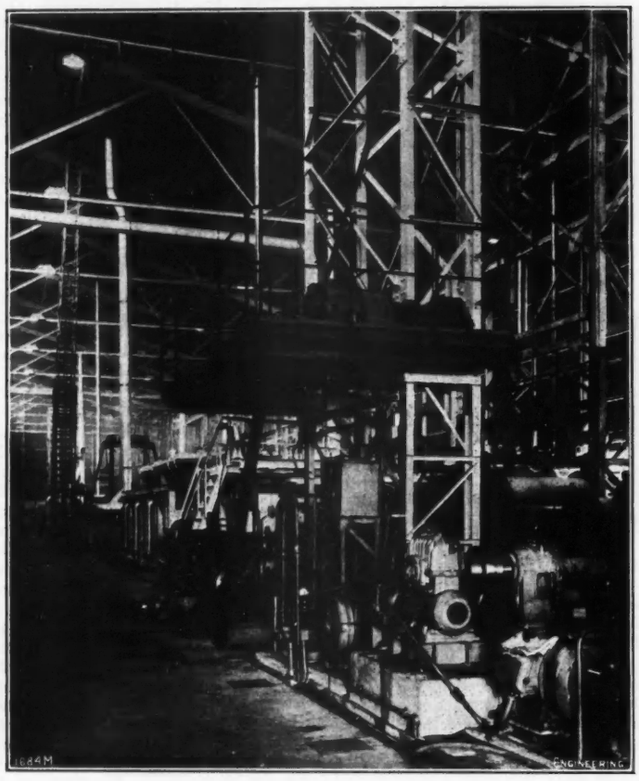

Fig. 16. Mechanical Looper at Entry to Hot De-Scaling Line.

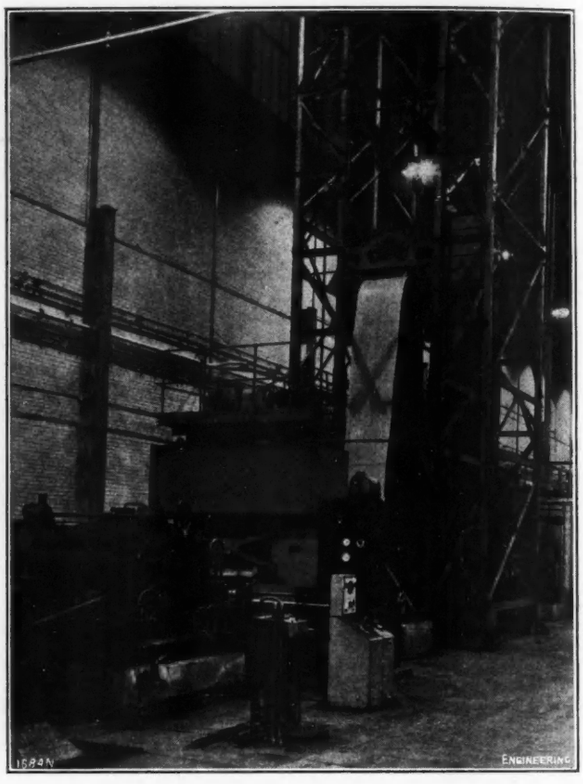

Fig. 17. Welder and Mechanical Looper.

the control gear for all the main and auxiliary drives which is mounted on an open-type board 120 ft. long. The auxiliary equipment in this part of the plant includes motors for driving the live rolls. These are supplied from separate motor-generators and are controlled on the Ward Leonard system in such a way that the roller and table speeds are matched and scratching of the strip is prevented.

Cold-Mill Drive.

The four-high cold reduction mill, which is illustrated in Fig. 20, is driven by a 1,500-h.p. 600-volt 375 to 750 r.p.m. forced-ventilated shunt-wound motor, which was manufactured by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. It is provided with a chain-driven tachometer-generator from which a speed reference for the Metadyne regulators is obtained. This generator also operates speed indicators on the control desk. Each reel is driven by a 600-h.p. 600-volt 500 to 1,000 r.p.m. forced-ventilated shunt-wound motor, which is equipped with a solenoid-operated brake and over-speed device. These motors are provided with chain-driven Selsyn transmitters for operating turn counters on the control desk. The up-coiler is driven by an 80-h.p. 300-volt shunt-wound totally-enclosed motor running at 1,000 to 1,200 r.p.m., which is also controlled by a Metadyne, and the leveller drive by a similar 50-h.p. 440-volt motor running at 1,200 r.p.m.

Power for operating the mill and reel motors is obtained from a motor-generator set consisting of a 2,400-h.p. 11-kV synchronous motor running at 750 r.p.m. and driving a 1,200-kW 600-volt and two 480-kW 600-volt generators. Excitation is provided by a 35-kW 250-volt constant-voltage machine and a 5-kW 230-volt exciter for the mill generator. There is also a 42-kW 440-volt generator for the leveller motor. All these machines are driven by a 125-h.p. 440-volt squirrel-cage motor running at 1,460 r.p.m. In addition the two 3-kW 250-volt reel motor Metadynes and the two 5-kW 250-volt reel generator Metadynes are driven at 1,460 r.p.m. by a 25-h.p. 440-volt squirrel-cage motor.

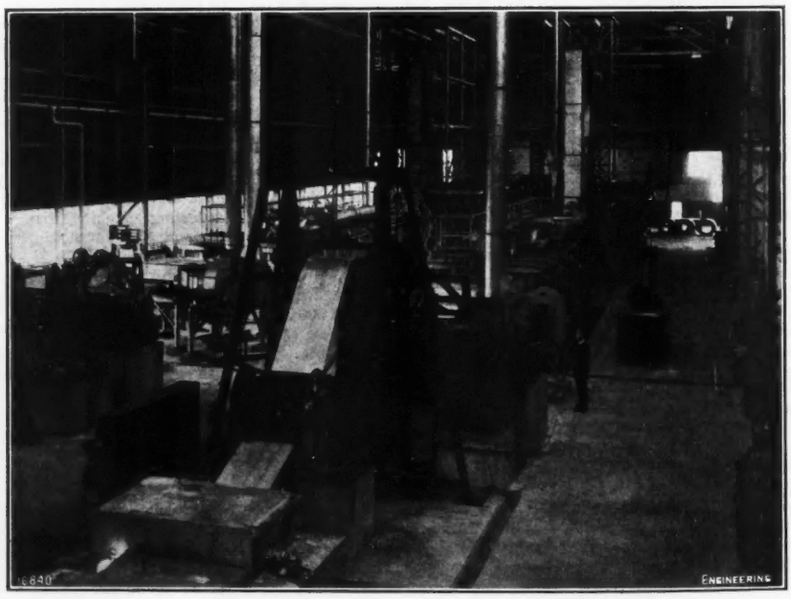

Fig. 18. De-Scaling Line in Operation.

As regards control, the 2,400-h.p. motor is reactor-started from a cubicle-type board near the motor-generator set and the mill-motor speed is regulated on the Ward Leonard system, a single motor-operated rheostat being used to increase the main generator voltage and subsequently to weaken the mill-motor field. Stopping can be effected in emergency by regenerative braking, which is brought into operation by separate contactors, tension in the strip being maintained by the Metadynes. At full load the winding-reel motor exerts a pull of 23,000 lb. in the strip, although this can be varied from 28,500 lb. at 25 per cent. overload to 4,500 lb. at one-fifth load. The control system installed for this purpose is designed to maintain a constant kilowatt input to the reel motors during the building up of a coil at any particular speed and to vary it in proportion to the speed. This is accomplished by varying the reel-motor voltage according to the strip speed and keeping the armature current constant after it has been adjusted to suit the tension.

(To face page 364.)

THE SHEPCOTE-LANE PLANT OF FIRTH-VICKERS STAINLESS STEELS, LIMITED.

(*For Description, see Page* 362.)

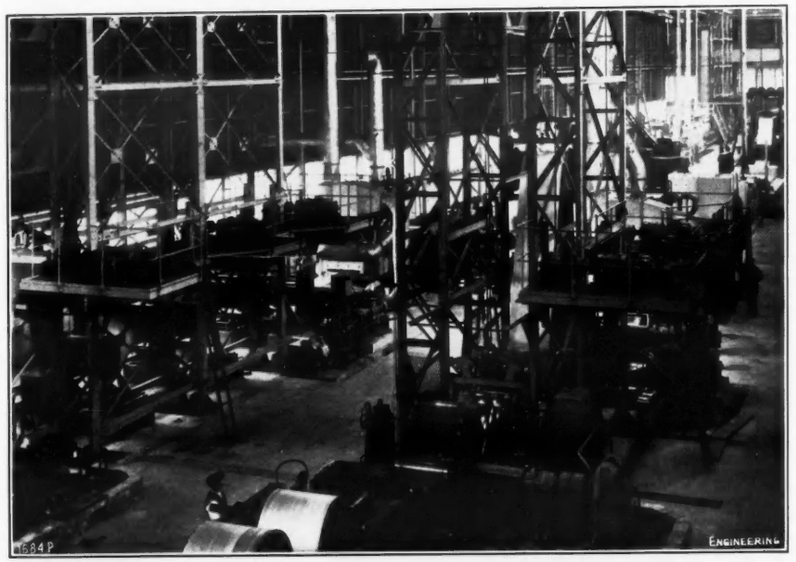

FIG. 19. EXIT END OF HOT DE-SCALING LINE.

FIG. 20. VIEW OF ROBERTSON MILL IN OPERATION.

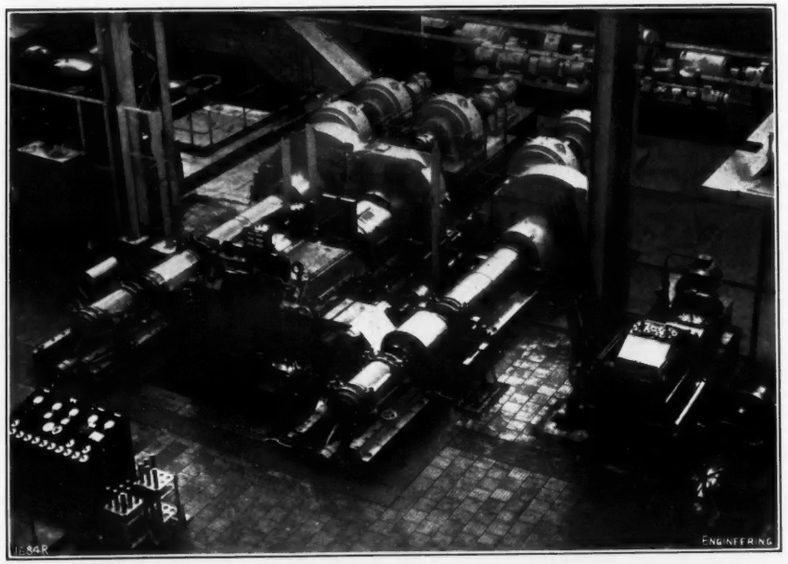

FIG. 21. SENDZIMIR MILL AND MOTORS.

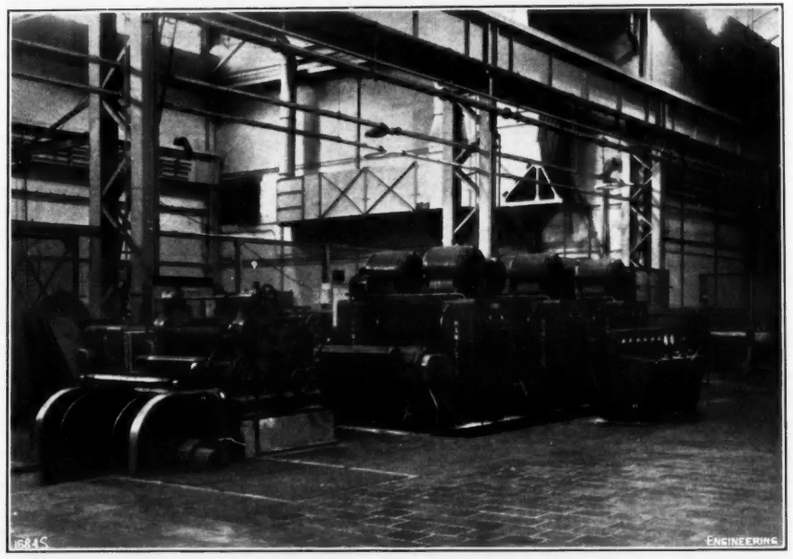

FIG. 22. HAMILTON GRINDING LINE.

SHEPCOTE-LANE STAINLESS-STEEL MILL.

FIG. 23. RE-COILING AND SLITTING LINE.

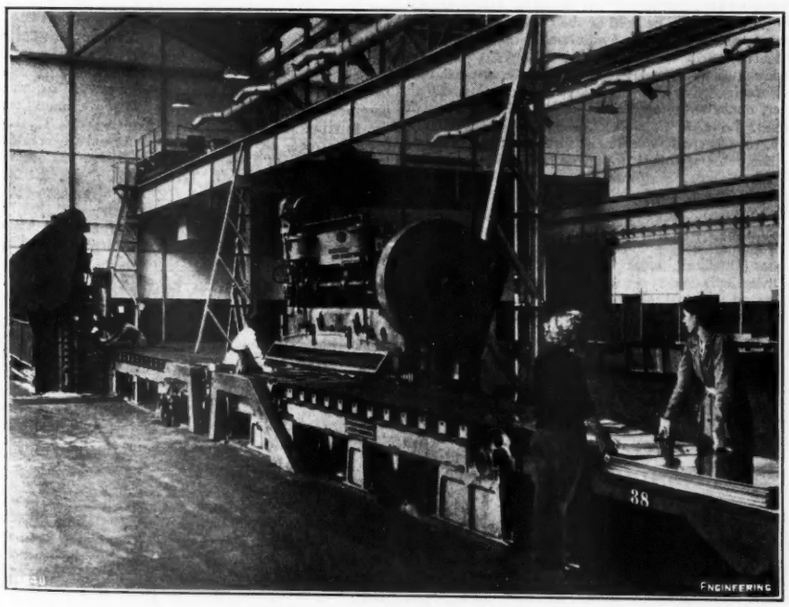

FIG. 24. BROOKES SHEARS IN WAREHOUSE.

The motor driving the Sendzimir mill, as already mentioned, was made by the English Electric Company, Limited. It is rated at 600 h.p. over a speed range of 500 to 1,000 r.p.m. and, like the boosters for the reel drives, is supplied from a variable-voltage generator driven by a 1,250-h.p. synchronous motor. Each reel is driven by two motors with an aggregate output of 430 h.p. over a speed range of 150 to 450 r.p.m. The object of the booster system is to ensure that the terminal voltage of these motors is proportional to the strip speed. A special tension-control system has been designed for this purpose so that inertia effects at the reels and the mechanical and electrical losses in the motors are automatically compensated. Control is effected from a desk near the mill, on which are lamps indicating when the mill control is available, the tension range, direction of rolling and whether the reel or leveller is being employed. There are also rheostats for adjusting the reel tensions and controlling the drag generator, as well as the control switches and emergency stop buttons.

ELECTRIC POWER SUPPLY.

A supply of power for operating the Shepcote-lane plant is obtained direct from the Blackburn Meadows power station of the British Electricity Authority at 33 kV. It is stepped down in a 15-MVA 33/11-kV transformer from which five distribution stations, located at load centres in the works, are supplied. The 11-kV network is also supplied direct from the public mains. The switchgear is of the oil and compound-filled, vertical isolation, single-break truck type, the fixed and moving portions of which are rated at 250 and 150 MVA, respectively, to allow for future extensions. The low-tension circuits in the plant are supplied through one 500-kVA and five 1,000-kVA transformers, with a secondary voltage of 440 volts, which are controlled by switchgear of the air-break horizontal draw-out truck type with a rupturing capacity of 25 MVA. Final distribution is through pedestal-mounted high-rupturing-capacity switch fuses.

A part of the cold mill bay near the Sendzimir mill is occupied by a three-stand tandem battery of strip-grinding machines, which were supplied by Hamilton Surface Grinders, Limited, Sheffield. These machines, of which an illustration is given in Fig. 22, Plate XXVI, are designed to deal with strip up to 42 in. wide on both sides at the same time and are used to remove minor surface defects prior to cold rolling. The battery consists of three grinding stands and four pass-line roller stands. Each of the former comprises two 24-in. steel drums, which are covered by a removable rubber sleeve that can be inflated like a tyre. Waterproof abrasive belts are wound spirally on the drums and are held in place by steel bands. When the rubber sleeves are inflated the necessary tension is created in these belts and can be adjusted by the air pressure to give the desired resilience or hardness to the drum.

In the Shepcote-lane warehouse, plant has been installed by W. H. A. Robertson and Company, Limited, to deal with material 42 in. wide and from 0·08 to 0·22 in. thick in 5-ton coils of 54 in. diameter by 26 in. bore. Flattened lengths from 36 in. to 12 ft. are produced at a speed up to 100 ft. per minute. These lengths are trimmed on all four sides by a line which has been equipped by Brookes (Oldbury), Limited. This line consists of two shears for cutting the long side of the sheet and a shear unit for squaring and cutting the ends. All these machines are connected by conveyors and are so arranged that handling is facilitated; also, to prevent damage from scratching, the conveyor belts and rollers are covered with rubber. The squaring shears are provided with two separate beams and blades—an arrangement which obviates the need for a deflecting table at the back of the machine. The sheet therefore remains flat on the track, ensuring perfect squaring at both ends.

Fig. 24 is an illustration of a machine which has also been constructed by Messrs. Brookes to deal with sizes smaller than can be conveniently cut on the unit just described. It can take 10-ft. sheets with a maximum thickness of 24 gauge and all measurements are taken from the front of the machine, no back gauge being used. The front gauging equipment consists of a series of collapsible stops, so that the sheet will press those below the table surface when placed in position. The sheets are given a preliminary trim on both sides and are then turned over and gauged against the first stop. This gives the strip the required size. The sheet is next moved forward and gauged against the next stop, the process being subsequently repeated. The strips can then be squared against a similar arrangement on the squaring arm. Operation is through a clutch, which is actuated by a solenoid, the latter being switched in by a series of pedals along the squaring arm.

INTERNATIONAL CARGO-HANDLING CO-ORDINATION ASSOCIATION.—At a meeting held in London on Friday, September 11, the officers of the International Cargo Handling Co-ordination Association reported progress to the United Kingdom members, who now number between 70 and 75. A symposium on Unit Loading and Palletisation is to be held on Thursday, October 1, on board the Wellington, Victoria-embankment, London, W.C.2.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

GRAPHITE DEPOSITS FOUND IN INVERNESS-SHIRE.—A geologists' report on a vein of graphite found in the Loch Lochy area of Lochaber, Inverness-shire, has been submitted by the Highlands and Islands Advisory Committee of the Scottish Board for Industry to the Scottish Home Department for consideration. Since it was prepared, landslides, caused by heavy rain, have uncovered further veins.

SALVAGE OF MAILLÉ BRÉZÉ.—The wreck of the French destroyer, Maillé Brézé, which sank in the Clyde off Greenock in 1940 after an explosion on board, is expected to be salvaged in the spring, said Mr. W. F. Robertson, chairman, at a recent meeting of the Clyde Lighthouses Trustees. The Admiralty, he added, hoped to complete the raising of the vessel after preliminary work, now being undertaken by divers to excavate the great accumulation of silt under the hull, had been finished. They also hoped to raise the vessel in one piece. The lift is expected to be about 4,000 tons.

SALVAGE OF CARGOES LOST DURING THE WAR.—Two salvage ships, the Flow and the Fertility, belonging to the Northern Shipbreaking Company, Peterhead, are engaged in the recovery of cargoes, lost at sea during the war, off the west coast of Scotland. Five hundred tons of shell cases lost from an American ship off the island of Gigha have been recovered.

BRITISH POLAR 1,700-B.H.P. ENGINE.—British Polar Engines, Govan, have built a new single-acting two-cycle engine of nine cylinders having a bore of 340 mm. and a piston stroke of 570 mm. It is designed to develop 1,700 b.h.p. at 300 r.p.m. on the continuous rating. The performance of the first engine to reach the test bed is said to have exceeded expectations. The new engine is intended to have a wide application for marine propulsion and as a stationary unit.

GERMAN STEEL PLATES ON THE CLYDE.—John G. Kincaid & Co., Ltd., Greenock, have purchased 500 tons of steel plates, including 300 tons of boiler plates, from Germany in an effort to relieve the difficulty they have encountered in giving delivery of ship-propelling machinery. Some of the material is expected this month, and the balance next month.

DEEP-WATER SEAWEED COLLECTION.—Frogmen are to be employed by the Scottish Institute of Seaweed Research off the Argyll coast during the next fortnight in experimental work with new equipment for cutting and collecting seaweed from deep water. They joined the institute's research ship Chondrus at Oban on September 8 and watched the operation of the cutting machines under water.

THE LATE MR. D. B. MARRS.—The death took place on September 8 of Mr. David Barrie Marrs, B.Sc., burgh surveyor and water engineer to Stirling Town Council since 1935. Mr. Marrs, who was 53, was an associate member of the Institution of Structural Engineers and of the Institution of Municipal and County Engineers.

CLEVELAND AND THE NORTHERN COUNTIES.

HOWDEN-JARROW ROAD TUNNEL.—The Government is to be asked to allow the 6,000,000*l.* scheme for a road tunnel under the River Tyne, between Howden and Jarrow, to proceed. The Tyne Tunnel Joint Committee of the County Councils of Durham and Northumberland, some years ago, drew up schemes for road, pedestrian and cyclist tunnels. Only the pedestrian and cyclist tunnels were allowed to proceed, and were completed two years ago at a cost of 800,000*l.* The road-tunnel plan was deferred on the grounds of economy.

DORMAN, LONG LACKENBY STEELWORKS.—Dorman, Long & Co., Ltd. have nearly completed the new open-hearth steelworks at Lackenby, North Yorkshire. This will mark the end of the second stage of the company's post-war development plan. The new steel plant includes four furnaces, each of 360 tons capacity. A fifth furnace will be added under stage three of the development programme, and will bring the annual output of the works to 625,000 tons of ingots.

SHIPBUILDING DEVELOPMENT AT BLYTH.—Blyth, Northumberland, Town Council have asked Blyth Dry Docks and Shipbuilding Co., Ltd., for further details of their proposed development scheme. It is understood that the shipbuilding company's long-term policy includes the construction of a dry dock and a building berth capable of accommodating ships of 30,000 tons. This plan would necessitate the acquisition of a considerable area of land adjoining the shipyard. The Town Council have promised the firm their assistance in carrying out the proposed developments. At present, the Blyth yard can build ships of up to 20,000 tons and is engaged on tankers of 18,000 tons. It has four building berths ranging from 300 ft. to 500 ft. and five dry docks ranging in length from 302 ft. to 460 ft.

EXTENSIONS AT MONKTON COKE WORKS.—Work is to begin on a 2,000,000*l.* extension scheme to the Monkton Coke Works of the National Coal Board, at Hebburn-on-Tyne. The Board have accepted the tender of the Woodall-Duckham Construction Co., Ltd., for the erection of a battery of 33 compound ovens and additional coal and coke-handling and by-products plant. The existing works were built in 1937. The extended plant will employ 180 men and use an annual quantity of 500,000 tons of washed coal, which will be drawn mainly from Kibblesworth, Burnopfield, Byermoor and Tanfield Collieries. All the coal will be cleaned in a new washery now under construction and additional coal may be obtained from the nearby Wardley Colliery, where a washery has been erected. The by-products will include sulphate of ammonia, tar and motor spirit, and 10,000,000 cub. ft. of gas will be purified daily and supplied to the Northern Gas Board. A pipeline eight miles long is to be laid along the old Bowes Railway to supply cooling water to the new works. Clarke, Chapman & Co., Ltd., Gateshead, are to erect a new water-tube boiler plant. The present coke works utilise about 200,000 tons of coal annually.

ALUMINIUM BRIDGE FOR ABERDEEN.—An aluminium bridge being built for the Aberdeen Harbour Commissioners, by Head, Wrightson & Co., Ltd., Thornaby-on-Tees, is to be officially opened by Queen Elizabeth the Queen Mother on September 30.

COURSES ON WELDING DESIGN.—Courses on the "Design of Welded Structures," organised by the constructional design department of the Quasi-Arc Co., Ltd., are again being arranged in various parts of the country, following the demand received last year. A course will be held at the Cleveland Technical Institute, Middlesbrough, commencing on October 27. The lectures will be given from 6 to 7.30 p.m., on Tuesday and Wednesday evenings, over a period of seven weeks, and guest speakers include Mr. R. J. Fowler, consulting engineer, and Mr. E. Ibbotson, of Dorman, Long & Co., Ltd. Further details of the course, together with enrolment forms, can be obtained from the constructional design department, Quasi-Arc Co., Ltd., Bilston, Staffordshire.

PERFORATED BUILDING BRICK.—William Leech, Ltd., builders and contractors, Newcastle-upon-Tyne, are producing a new type of building brick at their Coxhoe (Durham) brickyard. The brick is of the perforated wire-cut type, with a dimpled rustic facing. It is stated to be 20 per cent. lighter than the ordinary machine-pressed brick and the method of suspending the bricks to dry allows the air to circulate all round and ensures a more uniform texture. There are 20 ¼-in. holes through each brick, into which the cement enters to give a more durable bond. At present, the works are making 50,000 bricks weekly, but the output will shortly be doubled.

LANCASHIRE AND SOUTH YORKSHIRE.

THE LATE MR. F. P. I. CROSSLEY.—We note with regret the death of Mr. Francis Patrick Irwin Crossley, which occurred after a short illness on August 26. He was the grandson of, and heir to, Sir Kenneth I. Crossley, chairman of Crossley Brothers, Ltd., Openshaw, Manchester, 11, and joined the board of the company on September 19, 1950. He was the firm's youngest director.

SHEFFIELD STEEL PRODUCTION.—In August, Sheffield produced more steel than in July, namely, 33,600 tons a week compared with 32,700 tons. The August average of ingots and castings, however, was 4,000 tons below that of August, 1952, and 14,000 tons below that for the first half of the year.

SHEFFIELD WATER SUPPLY.—Sheffield's reservoirs, mainly in Derbyshire, are well filled, although the rainfall for the year, to the end of August, was 2 in. below the average. Sheffield has about a month's supply of water more than a year ago, in spite of an increased demand from industry. The absence of long dry spells has prevented stocks in the reservoirs from being depleted, and there has not been a notable loss of moisture in the ground due to evaporation.

UNIVERSITY DEPARTMENT OF MINING.—The Department of Mining at Sheffield University has been re-equipped and its accommodation virtually doubled by the extension of three floors and the addition of a new laboratory, at a cost of 45,000*l.* This has been done to provide adequate facilities for students attending the post-graduate school of mining, established at Sheffield last year. The head of the Department, Prof. I. C. F. Statham, states that the new facilities are intended to be used by pure scientists and engineers entering the industry, as well as mining students engaged on advanced work. The extensions are to be formally opened on October 7 by Sir Hubert Houldsworth, chairman of the National Coal Board.

THE MIDLANDS.

42-FT. VERTICAL BORING AND TURNING MILL.—Craven Brothers (Manchester), Ltd., Reddish, Stockport, have completed a fixed-column boring and turning mill believed to be the largest so far built in this country. This machine has a rotating work-table of 41 ft. in diameter and can take work-pieces weighing up to 100 tons, up to 42 ft. 6 in. in diameter, and up to 13 ft. 6 in. in height. The completed mill weighs 650 tons and will shortly be dismantled and shipped to Canada, where it will be erected to machine components of large hydro-electric plants. We expect to be able to publish an illustrated description of this machine, which has taken 2½ years to build, in a future issue of ENGINEERING.

THE LATE MR. FELIX HARMER.—We note with regret the death on September 10, after a prolonged illness, of Mr. Felix Harmer, the son of Mr. Oscar Harmer, a former general manager of Alfred Herbert Ltd., Coventry. Mr. F. Harmer served his apprenticeship in the works of Alfred Herbert Ltd., and was later appointed the firm's chief representative for equipment for the production of dies and moulds.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SPECIAL COURSES IN HIGHER TECHNOLOGY IN THE SOUTH-WEST.—A copy of a bulletin of special courses in higher technology which are being held in certain technical colleges in the South-Western region has been sent to us by the secretary of the Regional Council for Further Education for the South-West, 12, Lower Castle Street, Bristol, 1. The courses are conducted in the College of Technology and College of Commerce, Bristol; the Cornwall Technical College, Redruth; the Gloucester Technical College, Gloucester; the North Gloucestershire Technical College, Cheltenham; the Plymouth and Devonport Technical College, Plymouth, and the Malmesbury Institute, Wiltshire.

ADMIRALTY CONTRACTS IN WEST WALES.—It was reported at a recent meeting of the West Wales District Committee of the Welsh Board for Industry that approximately 250,000*l.* worth of Admiralty contracts were placed in West Wales district from August, 1952, to July, 1953. Such items as steel tubes, anchor and chain cable, steel plates and tin-plate were purchased locally. The shipyards at Pembroke and Milford Haven had increased Admiralty work during recent months and further vessels for refit and overhaul were expected.

PORT TALBOT LEVEL CROSSING.—The railway level crossing on the main West Wales road at Port Talbot, which is notorious for the traffic hold-up it causes, has again been discussed by the authorities concerned. Glamorgan Roads and Bridges Committee have agreed with the Railway Executive that the best and cheapest method to eliminate the trouble would be to raise the roadway above the railway.

WELSH INDUSTRIES FAIR.—The annual Welsh Industries Fair, held under the auspices of the National Industrial Development Council of Wales and Monmouthshire, opened at Cardiff on September 9 and closes to-morrow, September 19. Many types of manufactures are shown, the heavy coal, iron and steel industries being represented, as well as the many light industries now active in South Wales. Mr. A. G. B. Owen, chairman and managing director of the Owen Organisation, opened the exhibition.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTE OF METALS.—Monday, September 21, 6.30 p.m., Town Hall, Lord-street, Southport, Annual Autumn Lecture, "Titanium," by Dr. Maurice Cook. Tuesday, September 22, 9 a.m., and Thursday, September 24, 9.45 a.m., Town Hall, Southport, Annual Autumn Meeting. Wednesday, September 23 and Friday, September 25, various visits to works. For full programme, see page 170, *ante*.

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section:* Monday, September 21, 7 p.m., Midland Hotel, Derby. Presidential Address, by Mr. W. C. Puckey. *Manchester Graduate Section:* Tuesday, September 22, 7.15 p.m., Reynolds Hall, College of Technology, Manchester, 1, "Diecasting," by Mr. T. Bradshaw. *Shrewsbury Section:* Wednesday, September 30, 7.30 p.m., Shrewsbury Technical College, "The Engineer's Part in the Production of Pottery" (with film), by Mr. J. Robinson. *Reading Section:* Thursday, October 1, 7.30 p.m., The Great Western Hotel, Reading, Film and Discussion, "Forgings (High Duty Alloys)." *Lincoln Section:* Thursday, October 1, 7.30 p.m., Ruston Club, Unity-square, Lincoln. "Men and Machines," by Mr. J. E. Hall.

INCORPORATED PLANT ENGINEERS.—*Merseyside and North Wales Branch:* Monday, September 21, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Paint in Industry," by Mr. P. I. Gay. *Sheffield and District Branch:* Thursday, September 24, 7.30 p.m., Grand Hotel, Sheffield, Discussion on "Electrical Factory Regulations." *Yorkshire Branch:* Monday, September 28, 7.30 p.m., The University, Leeds, "Prestressed Concrete," by Dr. R. H. Evans. *London Branch:* Tuesday, October 6, 7 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Patterns, Castings and Foundry Works," by Mr. Barnet Levy.

INCORPORATED ASSOCIATION OF ARCHITECTS AND SURVEYORS.—Tuesday, September 22, 10 a.m., Institution of Civil Engineers, Great George-street, Westminster, S.W.1. Symposium on "The Testing and Stress Grading of Timber."

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*North-East England Group:* Tuesday, September 22, 7 p.m., Royal County Hotel, Durham City, "The Maintenance of High-Speed Diesel Engines," by Mr. H. L. Parrish. *London:* Wednesday, October 7, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2, Eighth Annual General Meeting, followed by "Transport in South Africa," by Mr. T. F. Turton.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, September 22, 5.30 p.m., 85, The Minories, E.C.3. Presidential Address by Sir Gilmour Jenkins.

INSTITUTION OF SANITARY ENGINEERS.—Wednesday, September 23, 6 p.m., Alliance Hall, Caxton-street, Westminster, S.W.1. "The Chlorination of Water," by Mr. E. A. Whitlock. Tuesday, September 29, 10.15 a.m. and/or 2.15 p.m., visit to Wallace and Tiernan, Limited, Power-road, London, W.4.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, September 23, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Presidential Address, by Mr. R. C. Bond.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Western Branch:* Thursday, September 24, 6.45 p.m., Engineers' Club, Albert-square, Manchester, "Design of Precision Grinding Machines," by Mr. C. H. Asbridge. *Western and Southern Branches:* Friday, September 25, 6.30 p.m., South Dorset Technical College, Weymouth, Joint Meeting, "The Electricity-Supply Industry," by Mr. E. A. Logan. *Southern Branch:* Wednesday, September 30, 7 p.m., Brighton Technical College. "The Railways and Coal," by Mr. R. G. Jarvis. *Institution:* Tuesday, October 6, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1, Annual General Meeting of the Automobile Division and Chairman's Address.

TELEVISION SOCIETY.—Thursday, September 24, 7 p.m., Cinematograph Exhibitors' Association, 164, Shaftesbury-avenue, W.C.2. "Transistors and Other Crystal Valves," by Mr. D. D. Jones.

ROYAL SANITARY INSTITUTE.—*Grimsby Sessional Meeting:* Thursday, September 24, 11.30 a.m., Town Hall, Grimsby, Joint meeting with the *East Midland District* of the INSTITUTION OF MUNICIPAL ENGINEERS, (i) "Grimsby Main Drainage: Combined Sewage and Surface-Water Pumping Stations," by Mr. S. W. Norman and (ii) "A Modern Abattoir," by Mr. Harold Parkinson.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Stoke and Crewe Branch:* Friday, September 25, 7.30 p.m., The Copeland Arms Hotel, Stoke. "Estimating and Economics of Electrical Contracting," by Mr. W. H. Brooks.

IRON AND STEEL INSTITUTE.—Wednesday, September 30, to Wednesday, October 7, Special Meeting in the Netherlands. See page 111, *ante*.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, September 30, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "The Impact of Communication Theory on Television," by Dr. D. A. Bell. *North-Western Section:* Thursday, October 1, 7.15 p.m., College of Technology, Manchester, "Parasitic Oscillations in Radio and Electronic Equipment," by Mr. H. Whalley.

INSTITUTE OF PACKAGING.—*Yorkshire Branch:* Wednesday, September 30, 6.30 p.m. for 7 p.m., Metropole Hotel, King-street, Leeds, 1, "Packaging at Rowntree and Company, Limited," by Mr. B. G. Brooks. *Southern Branch:* Thursday, October 1, 6 p.m., Waldorf Hotel, Aldwych, W.C.2. "Raising Packaging Efficiency in Small Firms," by Mr. E. D. S. Baker.

INSTITUTION OF ELECTRICAL ENGINEERS.—*East Midland Centre:* Thursday, October 1, 7.30 p.m., Masonic Hall, Pinchbeck-street, Spalding. "Overhead Transmission," by Mr. H. W. Grimmett and Mr. R. F. Proctor. *North Staffordshire Sub-Centre:* Friday, October 2, 7 p.m., Duncan's Hall, Stone, Chairman's Address, by Col. C. E. Calveley.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2, Park-street, London, W.1, at the price quoted at the end of each paragraph.

Acceptance Tests for Turbo-Type Compressors and Exhausters.—A new publication, B.S. No. 2009, is concerned with acceptance tests for turbo-type compressors and exhausters. It constitutes, with B.S. No. 1571, which relates to acceptance tests for positive displacement compressors and exhausters, B.S. No. 707, which deals with the testing of mine fans, and B.S. No. 848, which covers the testing of fans for general purposes, a series of codes for the testing of plant used for the movement of air and other gases. It is stated that arrangements are being made for the preparation of revisions of B.S. Nos. 707 and 848. In the new publication methods of test are specified for uncooled and cooled axial-flow and centrifugal compressors and exhausters, both when the test and guarantee gases are the same and when they are different. Methods of measurement are also specified and the instruments to be used dealt with. The method of correcting the test results, to allow for the difference between test and guarantee conditions, is then specified so as to provide an agreed basis by which guarantees given by manufacturers can be verified or comparisons of the performance made. A section on definitions and symbols, and clauses on the permissible deviation, the duration of a test, the induction-motor drive, the power consumption and the measurement of pressure, temperature, air flow and speed, are also included. Five detailed examples are given to illustrate the application of the standard to various conditions, and the theoretical basis of the publication is explained in an appendix. Moreover, the charts required for the calculations, and diagrams of typical test layouts are furnished. [Price 10*s*., postage included.]

Electricity Meters.—A sixth revision of B.S. No. 37: Part 3, dealing with single-phase two-wire prepayment meters has now been issued. The present publication applies to single-rate (flat-rate), multi-rate (load rate) and two-part tariff prepayment meters for systems not exceeding 250 volts. These comprise combinations of single-phase (two-wire) electricity meters and coin-freed mechanisms wholly or partially controlled by the meter. The standard ratings are 10 and 40 amperes. Certain features recommended for incorporation in future designs of meter are included in appendices. Part 1 of B.S. No. 37, concerned with general clauses applicable to all types of motor meters, and Part 2, covering single-phase, two-wire whole-current credit type meters, were published together under one and the same cover some months ago. [Prices: Parts 1 and 2, 4*s*., and Part 3, 4*s*., postage included.]

Accuracy of Circular Gear-Shaving Cutters.—A new specification, B.S. No. 2007, forms part of a series which will deal with gear-forming tools. It applies to serrated circular gear-shaving cutters having single or double cutting flanks. The publication specifies limits of accuracy only for such cutters, either new or completely re-ground, when intended for the production of gears of an accuracy comparable with class A1 of B.S. No. 1807: 1952, covering "Gears for Turbines and Similar Drives. Part 1: Accuracy." The tolerances given in the new publication are based on a specification prepared by the Mechanical Engineering Research Laboratory of the Department of Scientific and Industrial Research, entitled, "Accuracy of Gear-Shaving Cutters for Marine and Similar Drives." [Price, 2*s*., postage included.]

PERSONAL.

H.R.H. THE DUKE OF EDINBURGH, K.G., has been pleased to become an honorary member of the Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1.

MR. R. L. WALSH has been elected to be the 318th holder of the office of Master of the Cutlers' Company in Hallamshire for 1953-54, in succession to SIR HAROLD WEST. MR. W. G. IBBERSON has been elected Senior Warden and MR. R. P. PHILLIPS, Junior Warden. The Master Cutler-elect will be installed and the other officers will take up their duties on October 6.

MR. R. A. RIDDLES, C.B.E., M.I.Mech.E., M.I.Loco.E., who since October 1947, has been the full-time member of the Railway Executive responsible for mechanical and electrical engineering, and who was formerly a vice-president of the L.M.S. Railway, is to retire from the railway service on September 30.

MR. G. PICKERING, at present senior engineer surveyor at Liverpool, has been appointed principal surveyor to Lloyd's Register of Shipping at that port, in succession to the late MR. T. PRATT, M.C.

MR. T. R. PORTER, M.B.E., hitherto superintendent, control and radio department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, has been oppointed superintendent, control department. MR. E. T. W. BARNES, A.M.I.E. (Aust.), A.M.I.P.E., is to be superintendent and MR. A. J. R. VEALE, A.M.C.T., G.I.Mech.E., assistant superintendent, radio department.

MR. E. W. HUDDY has been appointed district Inspector of Factories for the Wolverhampton South district, and will operate from Queen's Arcade Chambers, Wolverhampton. Mr. Huddy's district comprises part of Wolverhampton and Dudley, Stourbridge. Brierley Hill, Halesowen, Amblecote, Rowley Regis and Seisdon.

MR. ROLT HAMMOND, A.C.G.I., A.M.I.C.E., has resigned as Editor of *Machinery Lloyd* and has resumed his work as a freelance writer on engineering subjects. His address is 54, New-street, Henley-on-Thames.

MR. H. BURROUGHES, F.R.Ae.S., has been re-elected President of the Society of British Aircraft Contractors, Ltd., 32, Savile-row, London, W.1, for 1953-54. The deputy president, MR. W. T. GILL, the vice-president, MR. J. J. PARKES, and the treasurer, SIR FREDERICK HANDLEY PAGE, C.B.E., have also been re-elected for a further year of office.

The regional offices in England of the BOARD OF TRADE and the MINISTRY OF SUPPLY are being combined and the following are to act as controllers of the combined offices. *Northern:* MR. K. G. SILLAR; *East and West Ridings:* MR. J. PATERSON; *North Midland:* MR. M. WEBER; *Eastern:* MR. G. ROBERTS; *London and South Eastern:* MR. C. S. TOSELAND; *Southern:* MR. F. A. SWANN; *South Western:* MR. J. H. LARRARD; *Midland:* MR. B. W. T. KAY; and *North Western:* MR. E. J. HOLFORD-STREVENS.

MR. P. CARRINGTON, A.I.M., has joined the staff of Macrome Ltd., Aldersley, Wolverhampton, as metallurgist.

MR. ROBERT BURNETT has retired after 42 years of service with the Cargo Fleet Iron Co. Ltd., Middlesbrough, including 31 years as steel-plant manager.

MR. J. H. GROVES has been appointed sales manager of the Power Plant Co. Ltd., West Drayton, Middlesex.

STEEL AND CO. LTD., Crown Works, Sunderland, are to open a new factory in Sydney, Australia, for the assembly of earth-moving machinery and handling gear, from parts sent from the firm's Sunderland Works. The new factory is due to come into operation early in 1954.

JOHN B. PILLIN LTD., makers of air compressors and lubricating equipment, have had their plans approved for extensive factory alterations at the Hartlepools Industrial Estate, West Hartlepool, County Durham.

THE SELSON MACHINE TOOL CO. LTD., North Acton, London, N.W.10, have been appointed sole agents in the United Kingdom for the French firm, ETABLISSEMENTS M. DE VALLIÈRE; the Belgian firm, ATELIERS PEETERS; and the German firms, RICHARD STUHLMANN & CO., ALFRED GAUTHIER, G.m.b.H., and PRAHOMA-WERK KEHREN & CO.

SWITCHGEAR AND EQUIPMENT LTD., Southam-road, Banbury, Oxfordshire, are negotiating an extension to their factory in Blantyre, Glasgow, sufficient to double their present floor space and to treble production.

W. H. HEYWOOD & CO., LTD., Bayhall Works, Huddersfield, have removed their London office from 54, Victoria-street, to Hope House, Great Peter-street, S.W.1. (Telephone: ABBey 1077-8.)

OLIVER PELL CONTROL LTD., Cambridge-row, Burrage-road, Woolwich, London, S.E.18, have been made sole selling agents for BESSON AND ROBINSON LTD., makers of relays, delay switches and timing devices, 6, Government Buildings, Kidbrooke Park-road, London, S.E.3.

ENGINEERING, MARINE AND WELDING EXHIBITION.

(*For Description, see Page* 357.)

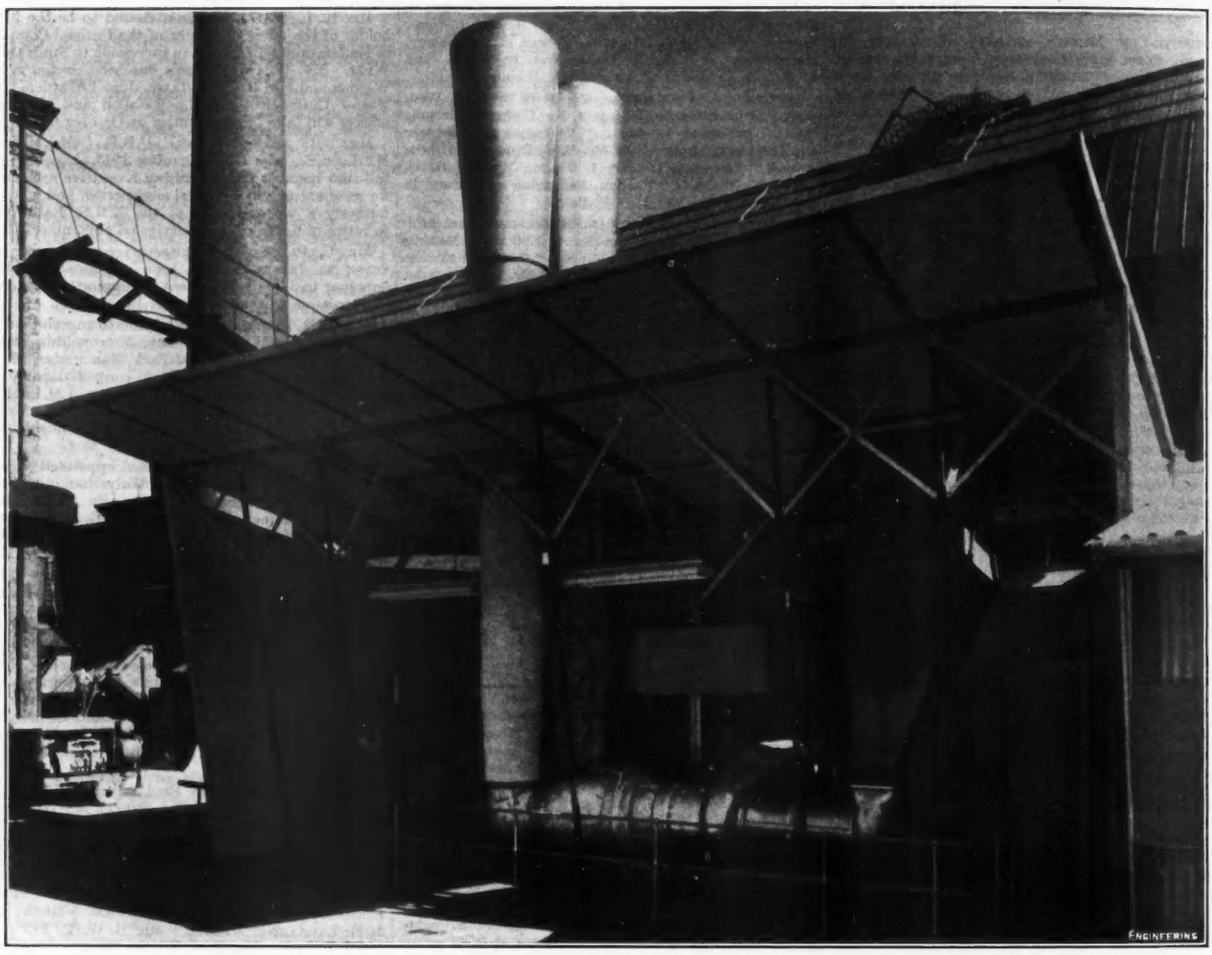

FIG. 125. INDUSTRIAL GAS TURBINE SUPPLYING POWER TO EXHIBITION HALLS; RUSTON AND HORNSBY, LTD.

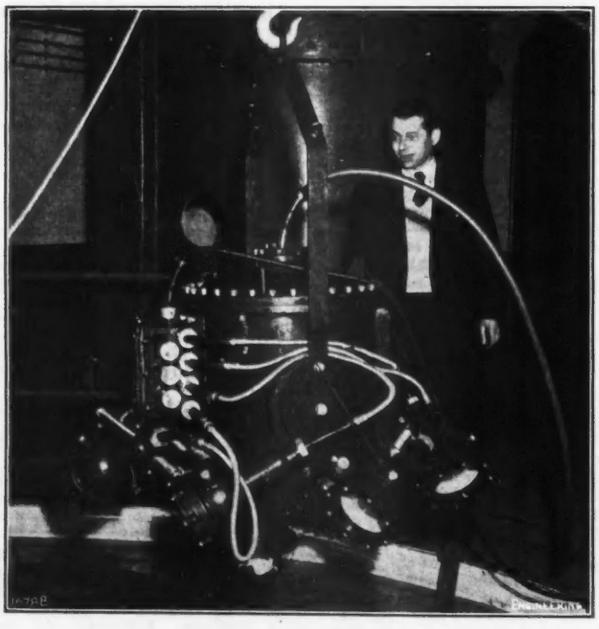

FIG. 126. MARCONI-SIEBE, GORMAN UNDER-WATER TELEVISION CAMERA; SIEBE, GORMAN & CO., LTD.

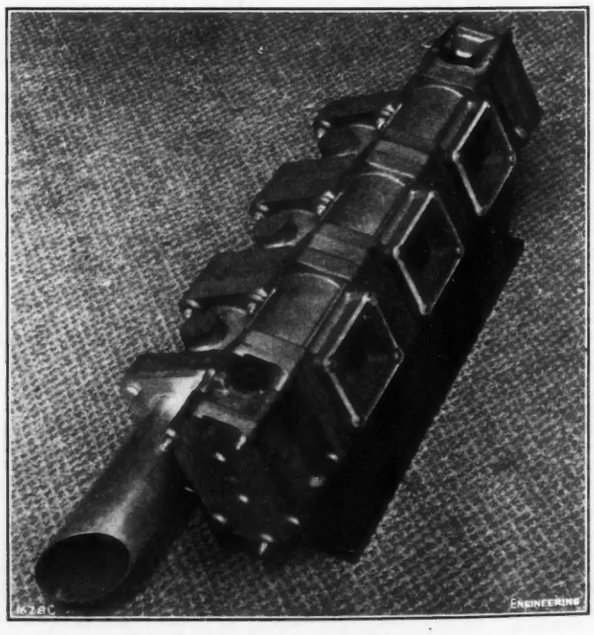

FIG. 127. EXHAUST TURBO-EXTRACTOR; WADE ENGINEERING, LTD.

ENGINEERING

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, SEPTEMBER 18, 1953.

VOL. 176. No. 4573.

MATERIALS HANDLING.

THE reports of the many teams that have visited the United States under the auspices of the Anglo-American Council on Productivity have, in practically every case, two features in common. They refer to the elaborate arrangements adopted for handling and moving materials in industries of every type and to the willingness with which the workpeople accept and make the best use of the various arrangements. It was stated in the report of the team dealing with mechanical handling that materials handling accounted for from 15 to 85 per cent. of the cost of production and added nothing to the value of the finished product. The important position which the cost of handling occupies in total cost is illustrated in another way in a recent report, in which it is stated that in spite of the intensive development of handling plant in the United States, the total cost of moving materials which in 1950 amounted to 9,000 million dollars could, by the installation of still more handling equipment, be reduced by 2,000 million dollars.

This latest report* is not a British one. It has been prepared by an international European technical mission which contained only one British representative, as against four from France, three from Germany, and two each from Austria, Belgium, Sweden and Italy. There was also one representative each from Greece, the Netherlands and Portugal. Some of these countries can hardly claim to be the sites of intensive manufacturing operations of the type with which discussions on materials handling are so frequently associated, but this report, although it is rich in technical detail, does not discuss factory lay-out and flow sheets in the manner, for instance, of the lecture entitled "How American Industry is Attacking the Problem of Materials Handling," by Mr. James R. Bright, which was delivered at a meeting of the Institution of Mechanical Engineers on April 17, 1953.

This international report is concerned, in the main, with the design of moving appliances and the interesting information provided, for instance, about the handling of bulk materials by belt conveyors, may be apposite in any country, industrialised or not. Before referring, however, in more detail to some of the information given, note should be made of the fact that the report is not concerned with the second of the two matters which occupy such prominent positions in the Anglo-American reports. It is stated that "labour relations were not studied in any detail, this being the province rather of national groups." Actually, nothing seems to be said in the body of the report about the formidable influence which organised labour can bring to bear when the introduction of labour-saving plant is under consideration. The "recommendations" appended to the report do, however, include the statement that in each individual country it is necessary to "impress upon labour the increased productivity and consequent higher standard of living which materials handling can bring about."

Whatever may be the case in other European countries, there is no doubt that one of the major problems facing a British "national group," when any question of improved handling appliances is under consideration, is the attitude of organised labour and how it is to be "impressed." It is in connection with what may be described as the non-craft unions that the greatest difficulties arise. Lord Waverley, at that time Sir John Anderson, once referred to a floating grain elevator at the Port of London, costing 150,000*l.*, which the employees refused to use because it was labour-saving. This matter is particularly pertinent to a reference, in the report, to ship-unloading conveyors. It is no doubt difficult to make workpeople realise that it is ultimately to their advantage that each individual should produce the maximum possible output, although it appears to be to a considerable extent accepted, even in this country, in highly-organised repetition manufacture. A striking illustration of the value of mechanisation was given in a Ford Sunday Evening Hour radio talk in the United States during the depression in 1935, when many of the operatives usually employed had been "stood-off." It was pointed out that the cost of making a Ford car by the methods of the general-engineering shop would be 17,850 dols., involving a price at which not fifty cars a year would be sold. It was mechanisation which had created the motor-car industry and provided a livelihood for the hundreds of thousands of people engaged in it.

This particular example illustrated the value of mechanisation in general, not merely its value in connection with materials handling, although this latter is a highly important factor in the overall result. Nevertheless, it may appear to dockers to have no relation to the unloading of ships; if it were possible, it would be well to "impress" them with the fact that increasing the cost of unloading grain will increase the cost of bread, which is one of the items in their own standard of living. It is possible that most people feel that labour-saving arrangements are of value in all occupations but their own. Opposition from those threatened arises even in America, as is illustrated in connection with an ambitious project, described in the report, for a belt conveyor, 130 miles long, to transport coal and ore between Lake Erie and the Ohio River. If the annual volume transported were 15 million tons, it is estimated that a saving of 1·06 dols. per ton would be shown, as compared with other means of transport. Opposition comes from the railway interests, as the traffic involved has a value of 62 million dols. per annum.

* *Materials Handling Equipment and Methods in the U.S.A.* Organisation for European Economic Co-operation, 2, rue André-Pascal, Paris, 16e. On sale by H.M. Stationery Office [Price 450 French francs, or 9*s.*]

The proposal is for separate conveyors, running in opposite directions, enclosed in a single casing; one would carry coal and the other ore. An attempt was made to design an arrangement using a single conveyor, the return section carrying material, but the unequal loads on the upper and lower belts, and considerations in connection with breakdown and the accumulation of material showed this to be impracticable. With the arrangement proposed, there would be 129 conveyors for coal, 6 ft. wide, and 211 for ore, 4 ft. 6 in. wide; eight-ply belt would be used and the longest section would cover 1¾ miles. This would not be the longest conveyor in the country as at Monongahela, near Pittsburgh, there is a conveyor 2 miles long, with a change of level of 328 ft. It has a steel-wire reinforced belt 30 in. wide and transports 216 tons of coal per hour.

The report gives a considerable amount of information about conveyor belting. As the belt is the most expensive item in a conveyor, American engineers always adopt the narrowest belt possible. It is stated that in Europe great importance is attached to the size of the largest pieces conveyed in determining belt width, but that in America this matter is of less importance as preliminary crushing is widely practised. A narrow belt necessarily involves high speeds for high capacity, and this introduces high tensile stresses. Normally, strength is obtained by increasing the number of plys and the quality of the material, but this may introduce troughing difficulties; compromise is necessary. Metallic-core belts have been introduced, but are costly and require careful handling when installed as an endless drive. Nylon fabrics have been found to have "far too great a degree of stretch." Steel belts, "widely used in Europe," are uncommon; only one example, in a bakery, was seen.

Slat and roller conveyors are apparently not greatly different from those found in Europe, but it is stated that "much greater importance is attached than in Europe to the accurate forming of roller ends." In wheel conveyors, "very little known in Europe," the rollers are replaced by a series of wheels, side by side, and spaced a few inches apart. They are stated to be particularly suitable for handling light loads. The goods carried move easily as the mass to be set in motion is much smaller than is the case with rollers. Curves are also particularly easy to negotiate as the wheels automatically adapt themselves to the different inner and outer speeds. Ball stages were also seen. These consist of steel balls, 1 in. to 2 in. in diameter, bedded on small balls in retaining housings. They enable heavy packages to be moved with ease in any direction; a flat under-surface on the goods moved is necessary.

A long section of the report deals with portable cranes, works tractors and fork-lift trucks, but, apart from the extent to which they are used, practice in this field does not appear to differ greatly from that of Europe. In a factory manufacturing air compressors, which was equipped with a large number of conveyors, there were 2·5 trucks or tractors per 100 employees. Electric trucks, although twice as expensive as petrol trucks, are the cheapest to operate as they last longer and require less time for overhaul and maintenance. In connection with materials-handling plant generally, one of the recommendations with which the report ends is that "specialisation among equipment manufacturers" should be promoted. Bearing on this, it is remarked, in the body of the report, that "the European manufacturer caters for the demands of his client as much as he can," while the American attitude is "this is our standard product. You should adapt your installation to suit our machine." Whatever other European manufacturers may think of this, those in Great Britain are likely to receive it with a wry smile, in view of the fact that for years they have been accused of doing precisely what the report states is the correct thing to do.

STREET LIGHTING PRACTICE.

ALTHOUGH the public thoroughfares have been artificially illuminated during the hours of darkness for centuries in order to protect wayfarers both from material hazards and human interference, the methods adopted to attain these objects could for long only be described as elementary. It was not, in fact, until 1836, when the Common Council of the City of London was authorised to erect and maintain street lamps to burn from sunset to sunrise, that the problem was properly tackled; even then the means available to carry out these duties were not well adapted for the purpose. This condition persisted until the early years of the present century, when the flat-flame gas burner and the electric arc lamp were succeeded by the incandescent mantle, high-pressure gas and, above all, by the gas-filled metal-filament lamp. The rapid advances which subsequently occurred may, in fact, be said to be due to the increasing utilisation of the last mentioned illuminant, the supremacy of which has only recently been challenged by electric-discharge lamps of various types. Nevertheless, the position is even yet not entirely satisfactory, since throughout the country there is a great deal of variety both in the quality and quantity of the street lighting provided; and, what is equally important, a good deal of administrative interference to hamper progress. It is only fair to say that this is at least partly due to the war, for while a Departmental Committee of the Ministry of Transport in 1937 laid down certain conditions, compliance with which was an essential preliminary to financial assistance, it was not until last year that it was possible to bring a British Code of Practice on street lighting into use. The result is that practice varies in different parts of the country, a state of affairs which is delaying the arrival of that uniformity which it is so desirable to attain.

It is therefore satisfactory to be able to record that a perusal of the papers presented at the annual conference of the Association of Public Lighting Engineers, which has been held in Liverpool this week, shows that those concerned are well aware of the tasks they have to face. This opinion is confirmed by an exhibition of the latest apparatus and equipment, which was held at the same time; and indicated the extent to which illumination theory is being turned, sometimes literally, into concrete practice. Now, it will not be denied that one of the most important present problems in this field is how to improve the admittedly low efficiency of light production and utilisation. The paper read by Mr. G. Fitton on "The Utilisation Factor in Public Lighting" forms a useful contribution to this subject. After dealing with the matter under the headings of light produced, capital resources and equipment, he propounded the pertinent questions whether the fullest and most effective use is being made of the light emitted from public street lanterns; whether the capital provided for this purpose is being expended in the best possible way; and whether existing installations, old and new, are giving the best possible service. It is true that he did not give categorical answers to these questions, but, as there is little doubt what these would be, he offered a challenge to those concerned which will, we hope, be accepted.

The same fundamental problem, that of efficiency, was dealt with from a different point of view by Mr. J. B. de Boer, in a paper on "Criteria in the Quality of Street Lighting." In evaluating these, he pointed out, the essential factors are that the luminance of the road surface must be as high and as uniform as possible and that the contrast between this luminance and the objects seen against it should also be a maximum. Moreover, the glare should not reach a value which would cause discomfort. Using these factors as a basis, Mr. de Boer provided some useful quantitative data for three types of installation, two of British and one of European origin, with the object of proving that if the measurement and computation of the luminance and glare of street lighting installations become common practice, progress towards improved quality will be facilitated. The correlated subject of "The Design and Manufacture of Street Lighting Lanterns" was dealt with in a paper by Mr. M. H. Moundson, in which he paid special attention to the problems of the fittings manufacturer; and in describing "Public Lighting in Belgium," Mr. A. Boereboom pointed out that, compared with practice in this country, the use of relatively low-power lamps and of the cut-off type of lantern is common. Central suspension of the lanterns is also still usual, and where columns are employed these are not so well designed and finished as ours, an item of information which may bring comfort to certain critics in this country who hold that improvement in this direction is badly needed.

A useful mass of technical information, which it is hoped will be carefully considered, was therefore made available during the Liverpool meeting. Chronologically, however, its presentation was preceded by a presidential address, in which Mr. C. C. Smith dealt with certain administrative and technical matters. In so doing, he emphasised the importance of co-operation between neighbouring street lighting authorities with a view to obtaining uniformity of illumination, especially along our main roads. This did not mean, he pointed out, that the same type of lighting must be used everywhere, since there was less risk in passing from a high-class fluorescent to a high-class mercury installation than from a good to an inferior installation of the same type. In fact, although standardisation was probably necessary from the economic point of view, and also to a certain extent from the technical aspect, it could easily be overdone, especially in so far as the design of columns was concerned. Mr. Smith was probably preaching to the converted when he offered the further criticism that the grants made by the Ministry of Transport for the installation and maintenance of lighting on trunk roads should not be encompassed by restrictive and dictatorial conditions. Although these conditions are imposed with the laudable object of saving capital, this is not, he said, the only factor which should be considered, especially at a time when increasing traffic provides an additional reason for leniency. In this connection we agree with Mr. Smith that closer co-operation between local authorities and the Government would provide a solution to this difficulty, although to secure release from the tentacles of central control will not be easy.

Finally, Mr. Smith pleaded for a reconsideration by the nationalised Electricity and Gas Boards of the charges made for street lighting, so that development should not be stultified, and for co-operation between neighbouring local authorities in the appointment of a lighting specialist, so that the smaller bodies, while preserving their autonomy, should be able to obtain the advantages of expert advice at no great cost to themselves. More co-operation on the technical side was also necessary, for while the manufacturers of equipment were willing to foster new ideas and to take part in tests with the lighting engineer to the advantage of both parties, there was still an urgent need for closer contact between the civil engineer and the lighting engineer on the subject of road surfaces. It was, of course, the duty of the former to provide an economic, hard wearing, non-skid road surface, but in doing so he tended to forget that this surface played an important part in providing that silhouette vision upon which good street lighting practice was at present based.

NOTES.

THE WILBUR WRIGHT MEMORIAL LECTURE.

On Monday, September 14, the Royal Aeronautical Society met in the lecture theatre of the Royal Institution to honour once again, in accordance with annual custom, the memory of Wilbur Wright. The 41st memorial lecture, in the fiftieth year after the epoch-making flight at Dayton, Ohio, was delivered by Professor N. J. Hoff of the Brooklyn Polytechnic Institute, following the precedent that in every second year the lecturer will be an American citizen. Professor Hoff, who has made considerable contributions to the science of aeronautical engineering, had chosen "Buckling and Stability" for the subject of his lecture and, after quoting an original letter now in the Library of Congress at Washington, in which Wilbur Wright had revealed his close attention to problems of structural strength, the lecturer referred in detail to his own research, both theoretical and practical, in which he has been taking account of rate and duration of loading in the strength of columns. He traced the modern theory of column strength from Sir Richard Southwell and Professor Theodore von Karman, both of whom were present in his audience though both had published their most significant contributions to this problem over 40 years ago. A vote of thanks was proposed by Mr. George Edwards, the well-known British aircraft designer, who expressed great appreciation of the virtuosity of the lecturer in having presented a complex thesis so fluently and lucidly. Before the lecture, the President, Sir William Farren, F.R.S., presented scrolls of Honorary Fellowship to Sir Geoffrey de Havilland, C.B.E., and Sir Arthur Gouge in person and to Lord Hives *in absentia*. The Society's Gold Medal and other awards for the current year were also presented by the President. Members and guests, including many overseas delegates to the 4th Anglo-American Conference now in session, adjourned after the lecture to a reception at the Society's headquarters in Hamilton-place.

THE CORNISH ENGINES PRESERVATION SOCIETY.

In the article on "The Cornish Engine in Cornwall," in last week's issue of ENGINEERING, reference was made to the Rostowrack engine, which has been removed from its original site in the china clay district of Cornwall and re-erected in the museum of Messrs. Holman Brothers, Limited, at Camborne. On Saturday last, September 12, the engine was formally handed over to the Society by the Rt. Hon. Viscount Falmouth, who set the engine in motion; it is now driven by compressed air instead of steam. The day's proceedings began in the morning when members of the Society were enabled to visit the 90-in. Harvey engine, still working at East Pool, and the 80-in. Robinson engine at South Crofty, both of which were mentioned in our article. In the afternoon, the party assembled at the cottage at Penponds in which Richard Trevithick lived for many years. The cottage has been presented to the Society by Mr. James Olivey, who owned it, and now bears a commemorative tablet, which was unveiled by Captain R. E. Trevithick, great-grandson of Richard Trevithick, who was introduced to the gathering by Lord Falmouth, President of the Society. The tablet bears the inscription: "Richard Trevithick/1771-1833/The Engineer/and/Pioneer of High Pressure Steam/Lived Here." From the cottage, the party proceeded to the museum, where the door was unlocked by Lord Falmouth with a key handed to him by Mr. Richard Gilbert, of the research and experimental department of Messrs. Holman Brothers, who was in charge of the re-erection of the engine. (It may be mentioned that Mr. Gilbert was recently awarded the British Empire Medal; though the "B.E.M." thus appended to his name has been interpreted by some of his colleagues as indicating "Beam Engine Maker.") Before opening the valve which controls the supply of compressed air to the engine, Lord Falmouth unveiled a tablet in the engine house inscribed: "Rostowrack/Cornish Rotative Pumping Engine/Presented to the Cornish/Engines Preservation Society/by the Right Honourable/The Viscount Falmouth/12th September, 1953." The tablet, of Delabole slate, was presented to the Society by Colonel Setchell, director of the Old Delabole Slate Company, Limited. Prior to the afternoon ceremonies, the members of the Society, with a number of other guests, were entertained to luncheon by Messrs. Holman Brothers, Limited, in the works canteen, the chair being taken by Mr. A. Treve Holman, M.I.Mech.E. After the ceremony in the museum, tea was served, and the Shell Film Unit's film, "The Cornish Engine," was shown to several successive audiences.

A HOUSE JOURNAL ON FOUNDRY DEVELOPMENTS.

The first number of a new publication entitled *Foseco Foundry Developments* has been issued by Foundry Services Limited, Long Acre, Nechells, Birmingham, 7. In an introduction, Dr. D. V. Atterton states that in the course of the firm's research work on the development of new products for improving foundry practice, a considerable quantity of information is collected which is felt may be of interest to foundrymen and metallurgists in general. The purpose of the new journal, which the firm intends to publish from time to time, is to make this information quickly available and to keep clients informed on the various development projects in hand. The journal takes the form of a series of articles giving accounts of results of research work and comparative tests on various products and processes, and five recent investigations carried out in the company's laboratories are described in this first issue. These deal, respectively, with the development of Kalmin sleeves (an insulating and permeable material for increasing feeder-head efficiency) and a routine test for fluxes, both by Mr. C. Hall; a comparison between the degassing efficiency of hexachloroethane and nitrogen on a typical aluminium alloy, and a miniature experimental cupola, both by Mr. F. M. Bunbury; and the reduction of melting losses on copper-base alloys, by Mr. F. W. Pursall. Further particulars regarding the new publication may be obtained on application to Foundry Services Limited.

THE NUFFIELD FOUNDATION.

Although the Nuffield Foundation owes its existence to the engineering industry, its main activities are of a non-engineering type. The substantial financial assistance which it is in a position to render is chiefly afforded to research in the medical and social sciences. The interest of its generous and far-sighted founder in these matters is well known, but, apart from that, it is possible that the implication of a remark from *The Story of the Rockefeller Foundation* which is quoted in the Eighth Report of the Foundation may have influence on the activity of the managing trustees. The point made in the quotation is that charitable trusts may be tempted to support matters having a popular appeal and which "ultimately would be taken care of in some other way." This latter remark certainly applies to many important engineering researches, and the trustees may feel that some of the medical and, particularly, the social-science investigations which they foster are not likely to be supported by other bodies. These remarks must not be taken to indicate that engineering and the physical sciences are neglected. The opposite is, indeed, shown by the report, which covers the year ended March 31, 1953. The most direct engineering allocation is 25,000*l*., spread over ten years, to establish the Nuffield Research Professorship of Mechanical Engineering at the New South Wales University of Technology. Examples of support for physical science are 25,000*l*. to the University of Cambridge for the electronic calculating machine; 20,000*l*. to the Clarendon Laboratory of the University of Oxford for low-temperature research; and 200,000*l*. to the University of Manchester for the Jodrell Bank radio-telescope. There are many other smaller grants. It is stated in the report that it is only in the social sciences that the Foundation is sometimes prepared to waive its normal rule against assisting societies, but it appears to have waived it in the case of the Australian and New Zealand Association for the Advancement of Science, to which a grant of 1,200*l*. a year, for three years, has been made.

WATER SUPPLIES IN THE UNITED KINGDOM.

As the representative of some 550 water-supply authorities engaged in supplying water to 95 per cent. of domestic and industrial users in the United Kingdom, the British Waterworks Association have issued a statement on the proposals, contained in the interim report on public ownership by the general council of the trade unions and elsewhere, that the water-supply industry should be nationalised. The proposals for nationalisation, they maintain, are based on three points: those of "universal" service, the elimination of waste and the necessity for increased investment in the industry; the statement deals with the points in turn. On universal service, the B.W.A. point out that supplying the remaining 5 per cent. of rural population with piped water must be an expensive operation; at the present, such work is undertaken with Government grants made available under the Rural Water Supplies and Sewerage Acts, the water authorities themselves having no powers to raise the necessary capital by surcharging the urban areas. The statement demands the authors of the nationalisation proposals to make it clear to residents of urban and industrial areas the means that are to be adopted to pay for universal services. On eliminating waste, the B.W.A. state that, at the moment, the average cost of water per 1,000 gallons is 1*s*. 6*d*., as compared with 1*s*. before the war, a state of affairs which the Association claims reflects a condition already far removed from inefficiency. On further capital investments, the statement points out that all new development schemes require sanction by the Government of the day and that the water industry, in common with other industries, has a large number of schemes awaiting Government approval. At the Trades Union Congress, a general resolution was passed giving approval to public ownership in principle, but no specific statement was made concerning the nationalisation of water supplies.

LETTER TO THE EDITOR.

THE PRESERVATION OF OLD ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—To those interested in the history of engineering, and particularly in the history of Fen drainage, it is a matter of considerable regret that in the whole 700,000 acres of the Fenland there has been preserved not one single example of a windmill-driven scoopwheel, a type of pumping engine on which the drainage of the Fens depended for over 150 years, and of which there were many hundreds in use even up to the first half of the Nineteenth Century until it was ousted by the steam engine. Now we are faced with the same melancholy sequence of events in the history of the steam engine, first supplanted by the oil engine, and then consigned to the scrap-heap. The first steam engine was installed in the Fens by the Littleport and Downham Drainage District in 1820, almost simultaneously with that of the Swaffham and Bortisham Drainage Board, acting on the advice of John Rennie. A few years later, in 1825, Joseph Glynn, of the Butterley Company, installed an engine in the Pode Hole pumping station, near Spalding, where, at the same time, was erected a smaller engine built by Fenton and Murray, of Leeds. These two engines still exist, although largely rebuilt, but I fear that their existence cannot be much prolonged. Then followed engines at March West Fen in 1826, Misterton Soss, Lincolnshire, in 1829, Littleport Fen in 1830, and then the Butterley engine in the Stretham pumping station of the Waterbeach Level Commissioners in 1831.

It is this last engine which has prompted my letter to you. Here we have a magnificent example of an early Nineteenth-Century beam engine, complete with scoopwheel, the former retaining all the essential features of its original design, although

in the latter part of the century modifications were made to the scoopwheel in order to cope with a falling land surface and lowered water levels. The engine is still maintained in excellent condition and, I believe, were the boiler plant as sound as the engine, this could be used practically, had not the drainage of the district been re-sited. Indeed, in 1937 the plant was run for several days continuously to cope with floods. Now my plea is that active steps should be taken to preserve this engine and scoopwheel as a striking example of the old steam pumping plants of the Fens. It has the distinction of being the seventh installed in the Fens as a whole, and the fifth in the Bedford Level. The only way in which such a plant should be preserved is *in situ*, where there is sufficient space, and where the original layout as a whole can be retained. The Waterbeach engine has the advantage of being housed in a building which is, subject to minor repairs, sound and waterproof. Thus at a small cost there could be created a lasting memorial to a significant phase in the history of Fen drainage, a history which, in spite of the social and economic importance of the drainage, receives something less than its due attention. As I have said, no trace remains to-day of the 700 or so windmill-driven scoopwheels which were working in the Fens at the beginning of the Nineteenth Century. If active steps are not taken urgently, the position of the steam engine will be the same, and the scrap-heap will claim the few last remaining magnificent examples of the art of the steam-engine builder. The Waterbeach engine is an outstanding example, and as such is worthy of a finer end than the scrap-heap.

Yours faithfully,

L. E. HARRIS, A.M.I.Mech.E.

Histon, Cambridge.

September 12, 1953.

[We are glad to be able to state, on the authority of the Clerks to the Waterbeach Level Commissioners, that the Commissioners are approaching the Ministry of Works with a view to the installation being scheduled as an "ancient monument."—ED., E.]

OBITUARY.

MR. CURTIS McGRAW.

WE have learnt with regret of the death, on September 10 at the age of 57, of Mr. Curtis Whittlesey McGraw, chairman of the board and president of the McGraw-Hill Publishing Company, Incorporated, New York, and chairman of the McGraw-Hill Publishing Company, Limited, London. The organisation founded by his father, Mr. James H. McGraw, has expanded in parallel with the increased ramifications of business, science and technology in this century, and under his direction it continued that great service of books and periodicals which is appreciated and respected in every industrialised country throughout the world.

Mr. Curtis McGraw was born in Madison, New Jersey, U.S.A. He served with the infantry in France in the First World War, reaching the rank of major, and after graduating from Princeton University in 1920 he joined the business. He gained experience in various departments before being appointed secretary and assistant treasurer of the book company in 1922. Five years later he became vice-president, treasurer and a director of the book company. In 1930 he was elected a director of the publishing company and in 1943 vice-president and treasurer of the publishing company. Mr. McGraw became vice-chairman of the board in 1948, and in 1950 he succeeded his brother, Mr. James H. McGraw, Junr., as chairman and president. Earlier this year President Eisenhower appointed him to an advisory board set up to study the American Post Office.

TEACHING ENGINEERING DESIGN.—Throughout last session, the Technical College, Gravesend, conducted an experiment in the teaching of engineering design and drawing-office practice. The students were organised, with section leaders graded from among themselves, as a works' drawing office, and instruction was based on the design of equipment and components suggested by industry. The head of the department, Mr. H. E. Etherington, M.I.E.E., A.M.I.Mech.E., would be grateful for suitable material on which to base further instruction.

THE BRITISH ASSOCIATION MEETING IN LIVERPOOL.

(*Continued from page* 344.)

ON the morning of Friday, September 4, the work of Section G was divided into two parts. Session A was concerned with future economic prospects of nuclear power and with applications of solar energy. The session was opened by the chairman, Mr. J. Eccles, C.B.E., who briefly introduced the author of the first paper, Dr. B. L. Goodlet, deputy chief engineer of the Atomic Energy Research Establishment, Harwell. Dr. Goodlet then read his paper, "The Outlook for Economic Nuclear Power," which was reprinted on page 345, *ante*.

ECONOMIC NUCLEAR POWER.

Having presented the paper, the author added that, since it went to press, some information had been published showing that the capital cost per kilowatt of a nuclear power station of American design was between two and four times as much as that of a conventional coal-fired steam power station. Nuclear plant having half the life of steam plant, its capital cost per kilowatt would thus be from four to eight times that of a steam plant. In considering overall costs, however, it had to be remembered that the day-to-day costs of obtaining nuclear power were less than that from coal. Dr. Goodlet concluded by reminding the members that it was only just over ten years since the first nuclear reactor went into operation, and yet to-day we were already building a nuclear power plant with confidence in the outcome.

Mr. M. C. Hartnell-Beavis, in opening the discussion, asked the author if he could give some information about the health hazards which had to be taken into account in connection with a nuclear plant. In reply, Dr. Goodlet pointed out that everybody knew that radioactivity was very dangerous, so that naturally precautions had to be taken. When asked if the total enclosure of the plant were possible, Dr. Goodlet said that it was. Mr. Hartnell-Beavis then asked if it were possible to say that there was practically no danger to health when the plant was running. To this question Dr. Goodlet replied that he was living quite close to the plant and had not suffered. In fact, he added, the accident rate was considerably less than half that applying in the average industrial factory, and no damage had resulted from radioactivity.

Professor W. J. Kearton said he understood there were rods for controlling the activity of the reactor, and he asked if the control rods were moved by human means or automatically, to which Dr. Goodlet replied that the control was automatic. Professor Kearton then asked whether, in such a power system, it was essential to have in the reactor a circulating fluid which was not the working substance of the prime mover. Dr. Goodlet said that it was not absolutely essential, but pointed out that most people seemed to think it was convenient. Professor Kearton thereupon made the point that quite an important loss of energy was involved in such an arrangement, but that if the working substance could be put directly through the reactor there would be a smaller loss of energy and of availability. Replying, Dr. Goodlet suggested that the working fluid might not be a substance which could be put through the reactor; moreover, there was some radioactivity inside the reactor, and the fluid which went through the heat exchanger also went into the turbine, and, for that reason, Professor Kearton's proposal was not desirable.

Professor J. M. Williams, speaking of heat exchangers, mentioned that sodium was one of the substances used, and asked whether others had been considered, to which Dr. Goodlet drew attention to the inclusive list of metals that had been published by the Americans, giving more information than he could give in the few minutes at his disposal. Professor Williams then asked at what point in the power system the main loss of radioactivity occurred. The pile, he added, was obviously very radioactive. Dr. Goodlet replied that the radioactivity was confined within the uranium metal; the metal was contained in a sealed envelope, and no radioactivity was released.

Professor J. A. L. Matheson, M.B.E., asked for information on the ultimate disposal of the uranium residues, to which Dr. Goodlet replied that there were about 30 elements mentioned in the literature, and it would be appreciated that their ultimate disposal was quite a long-term problem.

The chairman then asked the author a general question on the economics of the use of nuclear power. Assuming we were fully dependent on uranium as the prime material, we, in the United Kingdom, having no uranium, would presumably be faced with the prospect of importing the whole of our fuel resources, and he asked what were the economic prospects of a country in such a position. Dr. Goodlet replied that the question applied not only to uranium and other fuels, but to any raw material. He observed that the Swiss, who produced machinery and made use of their water power, had few natural resources, yet they were one of the most advanced industrial nations in the world enjoying a very high standard of living. A speaker asked if it would not be reasonable to establish plants in Africa, where there was a source of uranium and at least a potential supply of cheap electricity from the Victoria Falls and a few other such places. The "slugs" (containing fission material) could be made there and then exported all over the world. The author replied that that had occurred to him; but there were many factors to be considered.

The chairman, in expressing the thanks of the meeting to the author, said we must think of what the development described might mean in terms of technology and economics and, to put it bluntly, in terms of our ultimate survival as an industrial nation. Many other things which had burst upon the world with explosive force had been in due course translated into sources of very great benefit. To-day, we were only at an early stage of the development. Perhaps in 1973 those who attended the British Association meeting would hear another paper dealing not with the prospective advantages of fission processes, but with the realised advantages throughout a large part of the world.

APPLICATIONS OF SOLAR ENERGY.

After a brief interval, the business of Session A was resumed, and Dr. H. Heywood delivered his paper, entitled "Solar Energy: Past, Present and Future Applications." We commence to reprint Dr. Heywood's paper on page 377 of this issue.

The discussion was opened by Professor J. M. Williams, who asked what would be the merit of using dirty water as an absorbent for the rays. Dr. Heywood replied that that would be quite satisfactory; indeed, the use of a black dye in the water had been tried already. The casing could be either transparent or there need be no casing, the fluid running through either glass tubes or in a shallow trough. Where water was required at relatively low temperature (140 deg. to 180 deg. F.) the glass tubes could be immersed; that method had been applied in an early plant using ether as the working fluid below the surface of the water, which contained a black dye. Again, in connection with salt evaporation and the storage of heat in shallow lakes, the suggestion had been made that the water should be dyed black to give better absorption characteristics.

Dr. Sherwood Taylor asked if it would be possible to use solar energy as a source of low-grade heat for a heat pump, and thus obtain the energy at a higher temperature. Dr. Heywood replied that such a proposition had great possibilities in temperate climates. It was quite possible to store heat for a few hours, or for a few days, by the use of sodium sulphate or in large water tanks; but to store heat for weeks or months was very difficult. He felt that it was quite impossible to store heat in the form of water heated in the summer for later use in the winter because too great a heat loss would be incurred, but if conveniently situated, with a shallow lake or water reservoir, some heat could be stored with a temperature loss of only 10 to 20 deg. F., when perhaps the water could be used as a source of heat for a heat pump, so improving the effectiveness of the Patter.

Dr. C. A. Maunder-Foster queried whether, for power generation, it would be possible to use the principle of the hot-air engine. Dr. Heywood acknowledged that that was a very good suggestion;

AIRCRAFT PROPELLER-BLADE FORGING OF TITANIUM ALLOY.

FIG. 1. COMPLETED FORGING.

FIG. 2. DROP-FORGING IN PROGRESS.

one of his assistants, Dr. Finklestein, had developed a new form of hot-air engine expressly for that purpose, though it was only on paper so far. He believed that the principle would be quite practicable; hot-air turbines would be even better, but then the size factors would have to be considered.

Miss M. V. Griffith asked for Dr. Heywood's views on the collection of solar energy and its continuous use in conjunction with small heat pumps. In reply, Dr. Heywood intimated that a higher performance would be obtained from a heat pump if the water were preheated slightly by passing it through radiators on the roof or walls of a building. Again, it was a question of the economics of such an arrangement: of balancing capital charges against improved output. The periods of bright sunshine during winter in this country were relatively short, but in a country such as Canada the prospect was much better. Dr. K. E. A. Effat asked how the cost of small power units would compare with more conventional systems. Dr. Heywood replied that something like 200 sq. ft. of absorbent surface was at present required to produce one horse-power. By effecting improvements, that surface could be reduced to 100 sq. ft. per horse-power, which he personally considered to be the limit. It would then cost 150*l.* to 200*l.* per horse-power, as compared with a power-station cost of 5*l.* to 10*l.* per horse-power. Assuming, however, that the system were successful, it would have a life of, say, 20 years, with practically no fuel or maintenance costs. It would seem likely, therefore, that if such a unit were operated continuously at a good load factor in a tropical country for 20 years it would be economic.

The chairman, in closing the meeting, expressed the thanks of the members to Dr. Heywood for having given them the benefit of his work, which, although it might have only a small effect on the lives of people in the United Kingdom, was another example of the manner in which the possibilities of maintaining and extending the advantages of civilisation were being explored. The meeting was then adjourned.

(To be continued.)

AIRCRAFT PROPELLER-BLADE FORGING OF TITANIUM ALLOY.

THE advantages and drawbacks of titanium and its alloys were dealt with in a paper read, in January, by Major P. L. Teed, before the Royal Aeronautical Society and reproduced in ENGINEERING on pages 251, 341 and 413 of volume 175 (1953). Major Teed gives further information on the subject in a paper presented before Section G of the British Association at Liverpool on September 8. In this paper, which is to be published shortly in ENGINEERING, he refers to a "Handbook on Titanium Metal" issued by the Titanium Metals Corporation of America, New York, the United Kingdom agents for whom are Henry Gardner and Company, Limited, 2, Metal Exchange-buildings, Leadenhall-avenue, London, E.C.3. Among the advantageous properties of titanium-base alloys, to which Major Teed and the compilers of the handbook draw attention, are, briefly, their lightness, high strength-weight ratio, their remarkable resistance to corrosion by sea water and marine amospheres, their "impressively high" fatigue characteristics and their good impact resistance. Some emphasis is laid on the fact that, at room temperature and employing standard un-notched rotating-beam or push-pull test-pieces, the endurance limit of titanium and its alloys exceeds 50 per cent. of the ultimate static tensile stress of the materials.

On the negative side it is pointed out that titanium loses strength and becomes embrittled on continued exposure to temperatures above 1,000 deg. F. (540 deg. C.). Moreover, pure titanium has a tendency to creep, but this is engaging the attention of producers of the metal and some promising alloys giving satisfactory resistance to creep have been, and are being, developed. A troublesome defect of titanium and its alloys is described by Major Teed as their "quite deplorable rubbing properties," the materials possessing a "marked tendency to pick-up on themselves and on other metals." On this point, the handbook states that titanium has such a "tendency to gall that applications involving sliding contact are questionable until suitable coatings are perfected." On balance, it is obvious that, although a considerable amount of work has been carried out on the metal and its alloys, much yet remains to be done, but, as Major Teed states, as the present high price of the materials falls so will the ambit of their use widen.

That the titanium alloys are increasing in favour at the present time in various branches of engineering and particularly in aircraft and aircraft engine production is indicated by the photographs reproduced in Figs. 1 and 2, on this page. Fig. 1 shows an aircraft propeller blade, 8 ft. 4 in. in length, designed by the Hamilton Standard Division of the United Aircraft Corporation of the United States, and drop-forged, using closed-impression dies, by the Ladish Company, Cudahy, Wisconsin, from a piece of Ti-140A alloy supplied by the Titanium Metals Corporation. The propeller blade is destined for use in a special research project for the U.S. Air Force. The Ti-140A alloy has a density of 0·1688 lb. per cubic inch, and its percentage chemical composition is as follows:—titanium, 93·7; iron, chromium and molybdenum, 1·5 to 2·5 in each case; carbon, 0·04 to 0·07; tungsten, 0·01 (maximum); silicon, 0·02 to 0·04; oxygen, 0·20 (maximum); nitrogen, 0·10 (maximum); and hydrogen, 0·02 to 0·05. The tensile strength of annealed forgings in this alloy are stated to range from 56 tons to 65 tons per square inch, the yield point from 48 tons to 58 tons per square inch, the elongation on a gauge length equivalent to four times the diameter of the test piece, 12 per cent., and the Brinell hardness number from 300 to 340. The propeller blade has been produced by the Ladish Company in the large hammer shown in Fig. 2, above, which is an 80,000 kilogramme-metre drop-forging hammer of the counter-blow type.

SUPERCHARGED GAS ENGINE.—The National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne, have supercharged a four-cycle spark-ignition gas engine, reducing the fuel consumption to 7,000 B.Th.U. per b.h.p. per hour. Heat dissipation has not been increased and the cooling-water system remains adequate.

THE AIRCRAFT INDUSTRY'S DISPLAY AT FARNBOROUGH.

(*Continued from page* 331.)

THE most impressive demonstration at the Society of British Aircraft Constructors' annual flying display, which concluded on Sunday, September 13, was a formation flight of delta-wing aircraft, arranged by A. V. Roe and Company, Limited, Greengate, Middleton, Manchester. On September 4, the second prototype Avro Vulcan bomber aeroplane, powered by four Bristol Olympus turbo-jet engines, made its first flight, and was able to appear in the delta-wing flight, which comprised two Vulcan aircraft (the first prototype now being powered by Armstrong Siddeley Sapphire jet engines in place of the Rolls-Royce Avon engines with which it was shown last year), and four of the 707 series of research aircraft, each powered by a single Rolls-Royce Derwent jet engine. Fig. 4 shows a rehearsal of the flypast, with the Sapphire Vulcan only. The two large bombers were painted white; the smaller aircraft consisted of two 707A high-speed research aircraft, in red and orange, a blue 707A low-speed research aircraft (with dorsal air intake), and a silver 707C dual-control aircraft, which has been developed in order to familiarise pilots with the handling of delta-wing aircraft. This machine also made its first flight during this summer. The four-wheel bogie undercarriage main units on the Vulcan aircraft have been developed by Dowty Equipment, Limited, Cheltenham, Gloucestershire. All the Avro deltas, it may be recalled, are controlled by separate elevator and aileron flaps on the wing trailing edges, and are provided with dive brakes and tail parachutes. No landing flaps or leading-edge slats have been found to be necessary with the delta configuration, and there are no fixed tailplanes on these machines. On the large bombers, the engines are almost totally enclosed within the wing structure; as a result of all these refinements, the Avro Vulcans have an appearance of aerodynamic "rightness" that has never been surpassed. The delta-wing layout, in addition to its structural and aerodynamic advantages, also provides ample stowage space for fuel and military stores.

Another bomber development appearing in the display was the Mark 2 Valiant, illustrated in Fig. 5, which flew for the first time on Friday, September 4. Designed and constructed by Vickers-Armstrongs Limited, Weybridge, Surrey, it is, like the earlier Valiant, which first appeared two years ago, powered by four Rolls-Royce Avon turbo-jet engines. It differs from the Mark I in having a longer nose and a backwards-retracting bogie undercarriage.

"VICTOR" BOMBER AIRCRAFT.

The most interesting of the new aircraft appearing for the first time at the Farnborough display was the Victor high-speed long-range bomber aeroplane, designed and constructed by Handley Page, Limited, Cricklewood, London, N.W.2, and on order under the super-priority scheme. The Victor, which flew for the first time on Christmas Eve last year and has since been carrying out extensive development trials, employs a "crescent-wing" planform, in which the wing sweepback and thickness are proportioned so that the critical Mach number is the same at any point along the spar. This, it is claimed by the manufacturers, is particularly suitable for long-range flight at high altitude near sonic speed, since, while delaying the onset of shock waves, it suffers less from the control and aeroelastic problems that beset the straight swept-back wing, and allows the use of a higher aspect ratio.

The external characteristics of the Victor are well illustrated in Fig. 6, which shows the aircraft taking off with trailing-edge flaps extended and leading-edge flaps lowered. The double-tyred four-wheel bogies of the tricycle undercarriage have been developed by Electro-Hydraulics, Limited, Warrington. Large air brakes are fitted at the rear of the fuselage. The aircraft is powered by four Armstrong Siddeley Sapphire axial-flow jet engines, totally enclosed in the deep wing roots, each pair of engines being fed with air from a common root.

TRANS-SONIC AIRCRAFT.

Dives through the "sound barrier" were carried out by two Hawker Hunter and two Vickers-Armstrongs Swift single-seat fighter aircraft, both of which are in production for the Royal Air Force. The production version of the Swift, the F Mark 4, designed by Vickers-Armstrongs Limited (Supermarine Division), Hursley Park, Winchester, has more powerful armament than the earlier machine, and its Rolls-Royce Avon engine is fitted with reheat. It is expected that the Swift will enter service within a few months. Two variants of the Hunter, designed and constructed by Hawker Aircraft, Limited, were demonstrated—the record-breaking reheat-Avon-engined prototype machine in which Squadron Leader Neville Duke exceeded the existing world speed record at an average speed of 727·6 m.p.h., illustrated in Fig. 7, and the Mark 2 Hunter, sponsored by Armstrong Siddeley Motors, Limited, Coventry, which has a Sapphire turbojet engine.

AIRCRAFT INDUSTRY'S DISPLAY AT FARNBOROUGH.

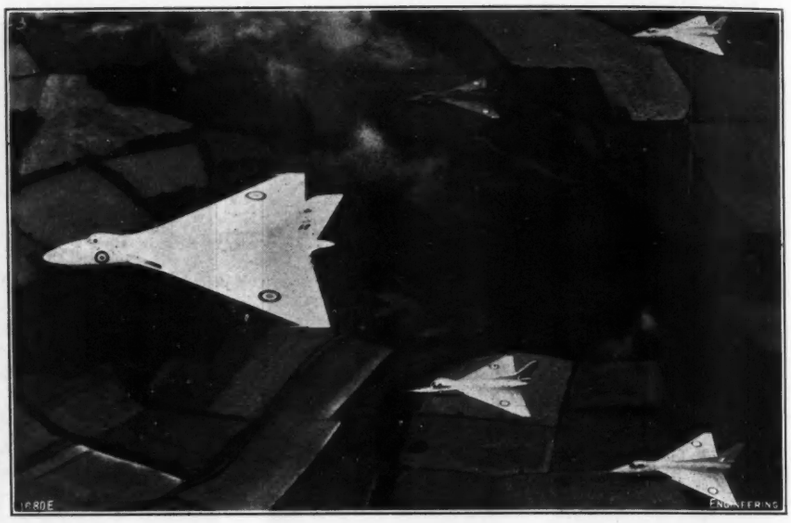


FIG. 4. AVRO DELTA-WING FORMATION FLIGHT.

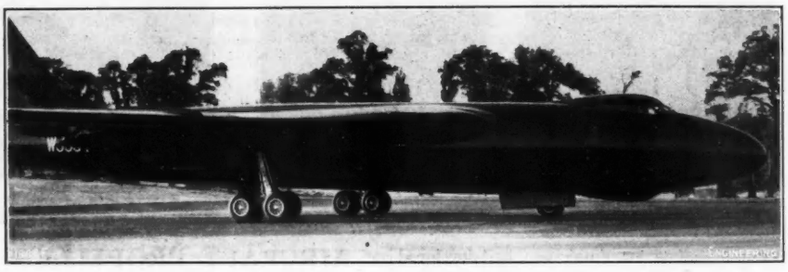


FIG. 5. "VALIANT" MARK 2 BOMBER AIRCRAFT.

FIG. 6. "VICTOR" BOMBER AIRCRAFT.

"SEA MEW" ANTI-SUBMARINE AIRCRAFT.

At the dinner given by the Society of British Aircraft Constructors before the opening of the

AIRCRAFT INDUSTRY'S DISPLAY AT FARNBOROUGH.

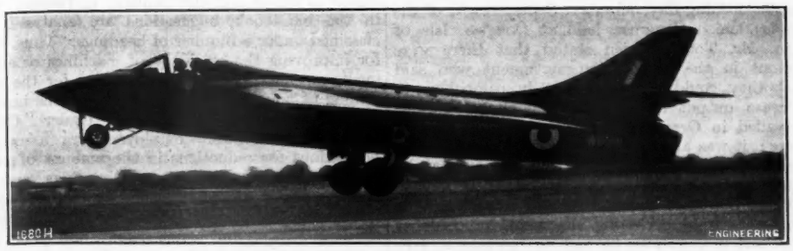


FIG. 7. RECORD-BREAKING "HUNTER" AIRCRAFT.

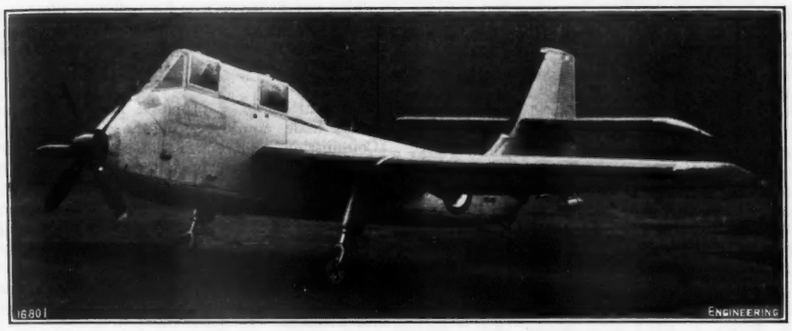


FIG. 8. "SEA MEW" ANTI-SUBMARINE AIRCRAFT.

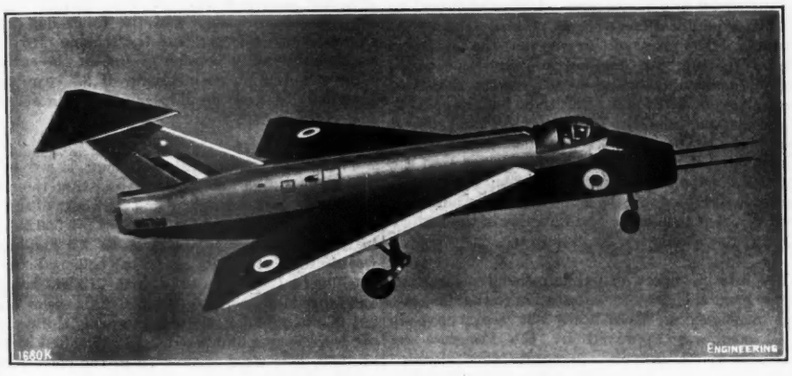


FIG. 9. SB5 VARIABLE-SWEEPBACK AIRCRAFT.

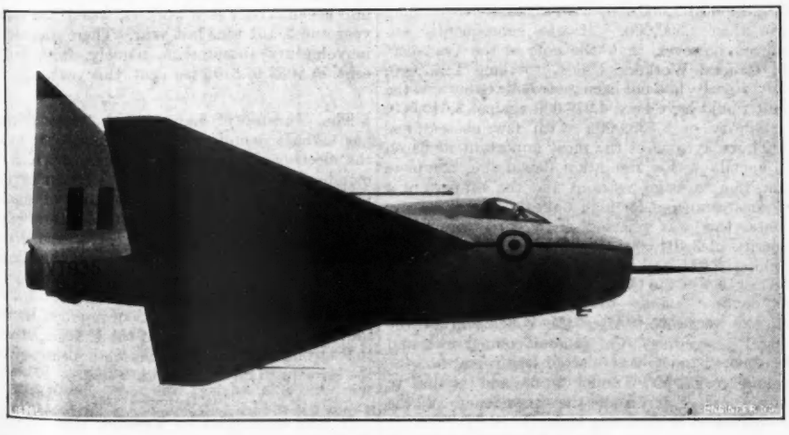


FIG. 10. P.111A DELTA-WING RESEARCH AIRCRAFT.

display, the guest speaker, Mr. Gordon McGregor, referring to the complexity of the modern fighter aircraft, said that it was difficult to believe that "any reasonable degree of serviceability could be achieved under operational conditions in the field with such a can of worms" or that "any nation could produce a sufficient number of skilled man-hours of work to make good the wastage. . . ." This opinion, now shared by many, can be applied equally well to other types of military aircraft.

The first visible evidence that the British aircraft industry is becoming aware of the necessity for simpler and more practical military aircraft was shown in the Sea Mew light anti-submarine aircraft designed and constructed by Short Brothers and Harland, Limited, Queen's Island, Belfast.

The Sea Mew, which is illustrated in Fig. 8, was designed and produced within 17 months of the receipt of instructions from the Ministry of Supply to proceed with its construction. It is on order for the Royal Navy and is intended for convoy protection, for operation from escort carriers or from merchant ship carriers. For this reason, it is designed to have an unusually low landing speed and good take-off characteristics. It has a fixed tail-wheel undercarriage and a deck arrester hook. The engine is an Armstrong Siddeley Mamba propeller turbine. The Sea Mew is of simple, sturdy construction, with a bomb bay in the fuselage, and carries an effective range of armament.

SB5 ADJUSTABLE-WING RESEARCH AIRCRAFT.

A research aircraft seen in public for the first time was the SB5 adjustable wing aircraft, constructed by Short Brothers and Harland, Limited, Queen's Island, Belfast. This aircraft has been designed to investigate the problems of handling swept-back aircraft at low speeds, and the sweepback of the wings can be adjusted, before flight, by fitting alternative components. The position of the variable-incidence tailplane relative to the fin can also be varied—it can be located either at the extreme top of the fin or below the fuselage. Four possible configurations are thus possible: 50 deg. sweep back with high tail unit, 60 deg. sweepback with low tail unit, 60 deg. sweepback with high tail unit, and 69 deg. sweepback with high tail unit. At Farnborough, the aircraft appeared, as shown in Fig. 9, with 60 deg. sweepback and a high tailplane. With this configuration, the landing speed is naturally high, and two braking parachutes were usually brought into use during the landing run. The aircraft has already completed seven months' flying with the wings set back at 50 deg.

The SB5 is powered by a Rolls-Royce Derwent engine, installed well aft of the pilot. The wings are of metal construction with plywood leading and trailing edges, and full-span leading-edge flaps. A fixed tricycle undercarriage is fitted, the attitude of which can be varied to enable test flights to be carried out at various centre-of-gravity locations. The pilot's cockpit is fitted with an ejector seat.

P.111A DELTA-WING RESEARCH AIRCRAFT.

The Boulton Paul P.111A, which has been developed from the P.111 delta-wing research aircraft, also flew for the first time in July, and is illustrated in Fig. 11. Like the earlier machine, which made its debut two years ago, it is powered by a Rolls-Royce Nene engine and, externally, is generally similar to that aircraft, with elevon control and a tail parachute for landing. This small delta-wing aircraft is capable of remarkably rapid manœuvres and is said to be among the fastest machines now flying without reheat. The latest aircraft has been provided with air brakes, consisting of four rectangular sections spaced at equal intervals round the fuselage. It will be observed also that a long "sting" has been added, projecting forward from the fuselage nose to carry a pressure head. Various internal modifications, about which no details have been released, have also been made.

(To be continued.)

THE OUTLOOK FOR ECONOMIC NUCLEAR POWER: ERRATUM.—On page 347, *ante*, in the paper "The Outlook for Economic Nuclear Power," given by Dr. B. L. Goodlet before the British Association, equations (4) and (5) were incorrectly printed. Equation (4) should have read

$$r = \frac{10^6\, b}{1{\cdot}08\, T_1\, L},$$

giving $T_1 = \dfrac{10^6\, b}{1{\cdot}08\, r\, L}$. Substituting this corrected value for T_1 in equation (3) of the article then gives

$$\tau = \frac{1}{g' - c}\left(\frac{10^6}{1{\cdot}08\, r\, L} + \frac{T_2}{b}\right) \text{days.} \quad . \quad (5)$$

ASLIB ANNUAL CONFERENCE.

THE Aslib Annual Conference, held at Nottingham University last week-end, included a number of meetings of value to engineers and engineering. A short paper by Mr. P. E. Colinese, B.Sc., described the adoption by the British Iron and Steel Research Association of the system of classifying metallurgical literature which has been developed by the American Society for Metals and the Special Libraries Association.

The great advances that have been made in recent years in the photographic reproduction of all kinds of documents were demonstrated by representatives of a number of firms. Single and multiple copies of material that is typewritten, printed, drawn, written in ink, etc., are now so cheaply and quickly produced by means of the latest machines that there are undoubtedly many offices where such a procedure could be adopted profitably for the first time. Among the other meetings were those dealing with the presentation of information; the information officer in relation to professional societies, trade associations, etc.; patents; fuel and power libraries and information services; and training and administration problems of special libraries. Professor Barbara Wootton, in her presidential address on "Some Problems of Communication," made her audience feel that never again could they read a newspaper leading article (even a *Times* first leader), without wishing for the statistical evidence which, strictly, is essential to many political and social arguments but is seldom quoted.

The system of classifying metallurgical literature described in Mr. Colinese's paper makes use of punched cards, only one card being used for each paper or report classified. By means of one or several needles, all cards on a particular subject are quickly separated from the rest. The system can, of course, be applied to other branches of knowledge. The A.S.M.-S.L.A. system, according to Mr. Colinese, allows up to about 10,000 cards to be handled comfortably. The proceedings of the conference are to be published by Aslib, 4, Palacegate, London, W.8.

INDEXING AERODYNAMIC DATA.

ON several occasions within the last two years, reference has been made in ENGINEERING to a scheme evolved by the Nationaal Luchtvaartlaboratorium (N.L.L.), Amsterdam, for card-indexing experimental aerodynamic data, in which the Aslib Aeronautical Group have been greatly interested, since the scheme appears to offer a solution to the difficult problem confronting aerodynamicists of tracking down particular wind-tunnel experiments from the increasing mass of data that is daily becoming available. As a result of recommendations by the Aslib Aeronautical Group, the Documentation Panel of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organisation have given their support to the N.L.L. scheme. Accordingly, the Nationaal Luchtvaartlaboratorium have launched the index on a commercial basis, and subscribers can now obtain cards at 2*s.* 3*d.* each, with an estimated supply of 1,000 to 1,250 cards a year. A detailed description of the scheme is given in N.L.L. Report F.125a, *The N.L.L. Card Catalogue of Aerodynamic Measurements*, by A. C. de Kock and A. I. Van de Vooren. Briefly, it comprises edge-punched cards which can be sorted mechanically or semi-mechanically—e.g., with a knitting needle. Each card contains complete detailed qualitative information of the contents of one particular document, but no results. The object of the card catalogue is to cover all published reports and articles containing aerodynamic data, using only one card per report. The cards can be sorted for information under one subject heading or under any combination of two or more subject headings. Small sketches on the face of the card show the general test set-up and the range of variables. The cards, and further particulars of the scheme, can be obtained from the Nationaal Luchtvaartlaboratorium, Sloterweg 145, Amsterdam W., Holland.

LABOUR NOTES.

IN the course of his presidential address delivered on the opening day, Monday, September 7, of the Trades Union Congress, held at Douglas, Isle of Man, Mr. Tom O'Brien stated that there were persons in the trade-union movement who said that they could not take part in campaigns to increase output so long as a capitalist society prevailed in Great Britain. This was utter nonsense; it was almost weak-minded to suggest that increased production meant more profit for the employers and none for anyone else. If anyone believed that trade unions were powerless to prevent employers from pocketing the whole proceeds of increased productivity he had no right to a place in that or any other congress.

On the question of the cost of living, Mr. O'Brien stated that if steps were taken to increase wages, it was a virtual certainty that the increased cost would be passed on to the consumer in increased prices, and most consumers were wage earners, a fact that was often overlooked. Hence, at present, every trade union accepted the principle that protection of its members did not lie wholly in securing an increase of money wages. It necessitated also a close scrutiny of economic policy and economic trends to safeguard the employment of the members. It required to be emphasised that, not only must there be a good rate for the job, suitably adjusted to price movements, but there must be a job available to which the rate applied.

At Tuesday's session of the Congress, attention was drawn to what were termed the "lowered standards of entry" for the factory inspectorate. One delegate stated that candidates having little or no industrial experience and without technical or scientific qualifications were at present accepted as entrants. The result of this was that the inspectorate which had been founded in years gone by to prevent accidents now did little more than examine the causes of accidents after they had happened. A speaker on behalf of the general council agreed that in the last series of examinations, the standards demanded had been reduced, and he added that the activities of the inspectorate were being maintained under close review by the council. He emphasised, however, that the ability and integrity of the factory inspectorate should not be underrated.

The interim report on public ownership prepared by the general council for submission to the Congress and mentioned in these notes last week, on page 344, *ante*, was approved by the Congress on Wednesday. A proposal to secure the reference back of the report because it was not considered to be sufficiently drastic was defeated on a card vote by 3,702,000 against 2,640,000, a majority against the motion of 1,062,000, with abstentions totalling more than 1,500,000. It was subsequently announced, however, that the vote of the Transport and General Workers' Union, totalling 1,277,000, inadvertently, had not been recorded. Otherwise the result would have been 4,979,000 against 2,640,000, a majority of 2,339,000; with few abstentions. On Thursday, one of the most important items on the agenda was a resolution demanding complete opposition to wage restraint and the support of a vigorous campaign for high wages. After a stormy debate, this was rejected on a card vote by a majority of 2,404,000, the votes for the resolution totalling 2,614,000 and those against, 5,018,000. The last day of the Congress, Friday, September 11, was devoted mainly to the discussion of international questions. After the conclusion of the general proceedings, the general council met and Mr. Jack Tanner was elected chairman for the ensuing year. Mr. Tanner is 64 and is due to retire, next year, from the presidency of the Amalgamated Engineering Union.

A suggestions handbook has recently been issued to every one of the 2,500 employees of the steelworks of Messrs. Edgar Allen and Company, Limited, Sheffield. The move has followed the formation of a Suggestion Scheme Committee, and the handbook is intended as a guide to suggestion-minded employees to think along the right lines. It is stated in "Target," a monthly bulletin on productivity issued by the Central Office of Information for the Board of Trade and the Ministry of Labour, that, in the handbook, suggestions are analysed and classified under a number of headings. Thus, ideas for improving the efficiency of machines or equipment, for new tools or machines, or for the positioning of machine controls, are under the heading of "Machines and Equipment." Under "Operations and Routines," employees are asked for suggestions for reductions in the amount of paper work, for the simplification of routings, and for improvements in office methods, while, under "Working Conditions," ideas regarding improvements in seating and bench height, and so on, and suggestions aimed at eliminating fatigue and strain are asked for. Of particular importance, of course, are the headings "economies" and "quality," which cover suggestions for reducing process times and maintenance costs, saving materials and power, and improving marking, packing and labelling techniques.

An outline of a proposed pension scheme for adult male employees of the British Transport Commission is given in the current issue of the *Journal* of the Amalgamated Engineering Union. It is shown that permanent staff in the wages grades of the Commission who have completed 12 months of continuous service and who are 21 years of age or over, will have an option to become members of Section A of the scheme, provided they are able, by the age of 65, to complete at least 20 years of continuous service with the Commission or its predecessors. In those cases in which a member completes 40 years of membership on reaching the age of 65, the weekly retirement pension is to be 30*s.*, one half of which will have been provided by his own contributions and the other half by the Commission. Section B of the scheme provides an additional weekly pension of 10*s.* at the age of 65 after a minimum membership of 35 years and is intended for male employees in certain scheduled senior grades.

The weekly statistical statement issued by the Ministry of Fuel and Power shows that the output of saleable coal during the first 35 weeks of this year totalled 147,351,000 tons, against 149,569,500 tons in the corresponding period of 1952. The average weekly total of employees on the colliery books was 720,100 in 1953, compared with 713,800 last year, and the face workers 300,500 this year against 291,600 in 1952. The average weekly shifts worked per wage earner numbered 4·59 in the first 34 weeks of 1953, compared with 4·75 in the corresponding period of 1952. The overall output per manshift was 1·203 tons this year to date against 1·188 tons in 1952, and the corresponding output, when taking into account only face workers, was 3·134 tons this year and 3·151 tons last year. There was a decline in voluntary absenteeism, namely, from 5·80 per cent. in 1952 to 5·05 per cent. this year.

The Minister of Labour and National Service has taken a definite step in an endeavour to settle the electricians' strike, as a result of which 4,500 members of the Electrical Trades Union have been idle. The Minister has set up a court of inquiry to investigate the causes and other matters relevant to the dispute, which is between the National Federated Electrical Association and the Electrical Trades Union. The court is sitting at the Royal Courts of Justice in London. Largely as a result of the setting up of the court of inquiry, Mr. W. C. Stevens, general secretary of the E.T.U., has stated that strong recommendations were being given to the strikers to return to work.

It was announced on Tuesday that an offer of an increase in wages made by the employers to dockers, stevedores and other port employees totalling between 75,000 and 80,000, had been rejected as unsatisfactory. The men's claim which is for a "substantial increase in pay" is now to be referred to the Minister of Labour and National Service under the Industrial Disputes Order.

SOLAR ENERGY: PAST, PRESENT AND FUTURE APPLICATIONS.*

By HAROLD HEYWOOD, D.Sc. (Eng.), Wh. Sch., M.I.Mech.E.,

THE sources of energy used by mankind for heating and power generation have almost all been derived from the energy radiated by the sun to the earth, but those that are most easily utilised have undergone natural processes of concentration.† Coal represents a concentration in time, the original vegetation having been subjected to solar radiation for many years during growth, apart from the millions of years required for the metamorphosis from plant to coal. Water power represents a concentration in space, for the water evaporated from a large surface area of ocean is deposited as rain over a watershed of lesser extent and is further concentrated in a lake the area of which is only a small fraction of that from which evaporation occurred. Facilities for water power are, however, limited to relatively few regions, and our reserves of coal and oil are decreasing and will eventually reach a stage of serious shortage.

Although solar-radiation energy is immense in quantity, it is relatively low in intensity; even so, the energy received on a surface one metre square placed normal to the radiation may amount to one kilowatt. To recover most of this, as heat, is not difficult, but to transform it to mechanical or electrical power involves substantial losses inevitable in such processes. Nevertheless, the advantages that would accrue to the inhabitants of partly developed countries where other sources of energy are lacking are sufficient to have attracted many minds during the past 100 years to the solution of the problems involved in the utilisation of solar energy. The situation is unlikely to be affected by future developments in the field of nuclear power production, for the problem will still remain of transmitting the energy through sparsely populated areas. No excuse is therefore needed for indulging in research on a subject which, though perhaps not of immediate moment, may in the future become of far-reaching consequence. This paper is a summary of what has been done in the past, of the present position, and the future possibilities.

Fig. 1.

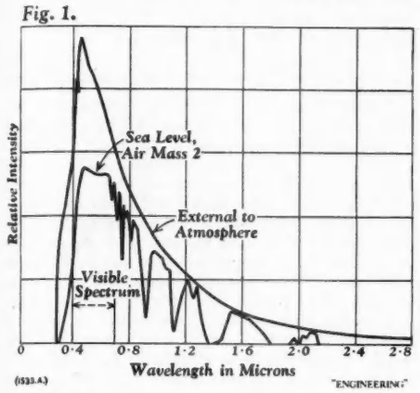
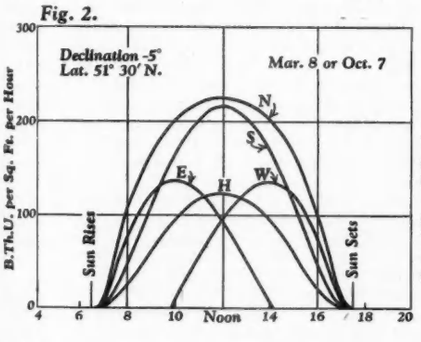


Fig. 2.



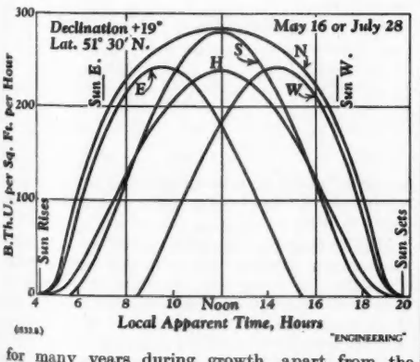


Fig. 3.

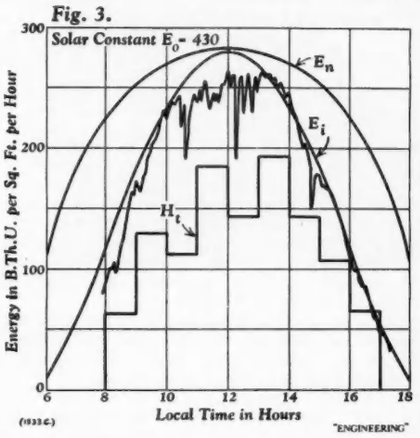
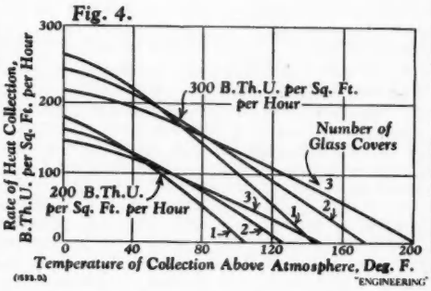


Fig. 4.



Solar Physics and Transmission of Radiation.

Since solar radiation is the raw material of power, a brief summary is given below of the elements of solar physics that affect the problems discussed in this paper.[1] The most important characteristic is the solar constant, or rate at which radiant energy is received external to the earth's atmosphere. This factor has been the subject of investigation for more than 100 years, and the generally accepted value at present is 1·94 calories per square centimetre per minute at mean distance from earth to sun.* The energy intercepted by the earth is only a minute fraction of that radiated from the sun at the rate of 6·3 kW per square centimetre, a rate of emission which corresponds to that of a black body at 5,900 deg. K., which may therefore be taken as the effective temperature of the surface of the sun. The source of this energy is now known to be the conversion of four hydrogen nuclei to a helium atom nucleus, though in the pre-atomic era many ingenious theories involving contraction were used in an attempt to account for this energy release. This nuclear transformation, according to Bethe, could involve a number of stages forming a complete cycle comprising various isotopes of carbon, nitrogen and oxygen. The cycle involves a mass loss of 0·028 of the mass of the hydrogen nucleus, aggregating the astounding total of four million tons a second, and the conversion of this mass to energy is the source of radiation.

The variation in the total rate of energy emission from the sun is very small, considering the observable variation in surface phenomena, such as sun spots, prominences and solar flares, and recorded values of the solar constant over many years are within ± 1·5 per cent. of the mean value. There is also a variation of ± 3·5 per cent. of the mean value due to changes in the distance from the earth to the sun, but these variations are insignificant compared with the variation in transmission through the earth's atmosphere.

The work of a number of scientists on the spectral distribution of solar energy has been correlated by Parry Moon, from whose data the curves in Fig. 1 have been plotted.[2] It should be noted that Moon considers that the Smithsonian Standard of 1913 used to assess the solar constant at 1·94 calories per square centimetre per minute is 2·3 per cent. high, and that the mean solar constant should be reduced to 1·896 calories per square centimetre per minute (1,322 watts per square metre). The proportions of the total energy in the ultra-violet, visible light wavelengths (0·4 to 0·7 microns) and infra-red regions, according to the air mass through which the radiation is transmitted, have the value shown in Table I.

Direct radiation is scattered by the gases in the atmosphere and by dust, and there is selective absorption by these gases, by ozone and water vapour. The effect of cloud and haze is however of over-ruling importance, and is the cause of very large variations in the radiation finally transmitted to sea level. The air mass is defined as the relative thickness of atmosphere through which the radiation passes, unit air mass being at sea level with the sun in the zenith position.

TABLE I.—SPECTRAL DISTRIBUTION OF SOLAR ENERGY (PARRY MOON).

Range of Wavelengths (Microns).	Percentage of Total Energy Transmitted.					
	$m = 0$	1	2	3	4	5
Ultra-violet—						
0·29–0·40	7·2	4·3	2·7	1·6	1·1	0·6
Visible—						
0·40–0·70	40·8	45·2	44·3	42·6	40·4	38·1
Above 0·70	52·0	50·5	53·0	55·8	58·5	61·3
Total energy, watts per square metre	1,322	928	740	607	509	430
B.Th.U. per square foot per hour	419	294	235	192	161	136
Transmission coefficient, q.	—	0·702	0·748	0·771	0·788	0·799

The angle between the zenith and the directions of the sun is the zenith distance, z. If it is assumed that the surface of the earth is flat, or alternatively that the thickness of the atmosphere is negligible compared with the radius of the earth, then the air mass is equal to sec z. This expression would give an air mass of infinity at sunset or sunrise, when z is 90 deg. but because of the curved surface of the earth there is a finite though large air mass. The secant expression is however sufficiently accurate for z up to 80 deg., and beyond this angle solar radiation is so greatly reduced that it has no practical value.

The radiant energies respectively incident upon and transmitted by an absorbing layer are related by the following expression:

$$\frac{E_n}{E_0} = q^m, \quad . \quad . \quad . \quad (1)$$

where E_n is the energy incident upon a surface normal to the direction of the sun, E_0 is the solar constant external to the atmosphere, m is the air mass, and q is the transmission coefficient for unit

* Paper read before Section G of the British Association at Liverpool, on Friday, September 4, 1953.

† See Appendix, to be given in concluding part of this paper.

* Equivalent to 429 B.Th.U. per square foot per hour, or 1,354 watts per square metre.

air mass. This expression is a simplification of the transmission characteristics of the atmosphere, for q is not independent of the air mass, as shown by the values in Table I. Also, q is less in summer than in winter because of the greater total water-vapour content of the atmosphere in summer. The lowest value for clear-sky conditions appears to be about 0·62, and the maximum 0·81; a mean value of 0·7 has been used for the calculations which follow.

The incident energy per unit area will be reduced if the receiving surface is not normal to the direction of the sun, and the relative values are shown by the following equation:

$$\frac{E_i}{E_n} = \cos i, \qquad . \quad . \quad (2)$$

where i is the angle of incidence measured from the normal, E_i is the incident energy per unit area on the inclined surface and E_n the energy which would be received per unit area on a normal surface. If the receiving surface is horizontal, then $i = z$, and

$$\frac{E_h}{E_n} = \cos z. \qquad . \quad . \quad (3)$$

The problem of assessing the rate of incidence of solar energy on a surface which is tilted to the horizontal and faces in any direction from East through South to West may be solved by means of the method described below.

Definitions.

h = hour angle, the apparent rotation of the celestial sphere about the earth's axis. Measured westwards in degrees from the South Meridian, 1 hour = 15 deg.

δ = declination, the angle of the sun measured above or below the celestial equator towards the pole.

ϕ = latitude of position on the earth's surface.

a = solar altitude above horizon = 90 deg. $- z$.

A = azimuth of sun, i.e., angle measured in a horizontal plane westwards from the South Meridian. (Astronomers usually measure azimuth from the North Meridian, but the above convention is more convenient for solar computations.)

The following equations are used for the conversion from celestial to terrestrial co-ordinates:

$$\sin a = \cos z = \sin \phi \sin \delta + \cos \phi \cos \delta \cos h \quad (4)$$

$$\sin A = \frac{\cos \delta \sin h}{\cos a}, \qquad . \quad . \quad . \quad . \quad (5)$$

$$\cot A \sin h = \cos h \sin \phi - \tan \delta \cos \phi \quad . \quad (6)$$

The latter equation is more accurate when A is approximately 90 deg.

Given the latitude position, the solar declination which depends on the time of the year and an hour angle which depends on the time of day measured from local noon, then the zenith distance may be calculated from equation (4). The intensity of radiation on a normal surface may then be calculated from equation (1), for $E_0 = 430$ B.Th.U. per square foot per hour, $q = 0{\cdot}7$ and $m = \sec z$. Let the absorbing surface be tilted at an angle θ degrees to the horizontal and face a direction α measured in degrees westward along the horizon from the South Meridian, e.g., α is 45 deg. for a south-west facing surface. The radiation intensity E_n is then split into components respectively perpendicular to and parallel to the tilted surface, the former only being effective. The final equation, in which E_i is the radiation intensity on the tilted surface, and for which limitations of space do not permit the full proof, is as follows:

$$\frac{E_i}{E_n} = \cos i = \cos (A - \alpha) \cos a \sin \theta + \sin a \cos \theta. \quad (7)$$

Fig. 2, on page 377, shows the variation in direct radiation intensity on surfaces that are respectively normal to the sun, horizontal, tilted 40 deg. to the horizontal and facing East, South or West. These curves have been calculated for declinations of -5 deg. and $+19$ deg., and the total energies received per square foot of surface during the day are given in Table II. The reference letters used in Fig. 2 have the following meanings: N = normal to the sun; H = horizontal; S, E, W refer to surfaces tilted at 40 deg. to the horizontal and facing South, East and West, respectively.

The total radiation received on a surface that is horizontal, or nearly so, is the sum of the direct radiation and the diffuse or scattered radiation. The former comes from the line of direction of the sun and may be calculated according to the angles concerned, but the latter comes from all parts of the sky and is not amenable to mathematical computation. This diffuse radiation is by no means negligible in magnitude, and while on clear bright days it may only amount to 10 per cent. of the total radiation on a horizontal surface, on partly cloudy days it may amount to more than 50 per cent., while on completely cloudy days it comprises the total radiation.

TABLE II.—*Direct Radiation, in B.Th.U. Per Square Foot Per Day.*

Attitude of Surface.	Declination and Date.	
	− 5 Deg. March 8 or October 7.	+ 19 Deg. May 16 or July 28.
Normal to sun	1,625	2,947
Horizontal	715	1,895
Tilted 40 deg. to horizontal and facing south	1,290	2,005
Tilted 40 deg. to horizontal and facing east or west ..	623	1,576

It is now possible to summarise in the form of a number of coefficients the factors that determine the amount of energy that may be received under different atmospheric conditions. Thus:

Air Mass Factor, $\frac{E_n}{E_0}$, depends on the latitude, the time of year and the time of day.

Attitude Factor, $\frac{E_i}{E_n}$, depends on the position of the energy-receiving surface as regards angle of tilt and facing direction.

Cloud and Haze Factor: depends on meteorological conditions.

Diffuse Radiation Factor, E_d, depends on meteorological conditions and attitude of receiving surface.

The picture presented by the analysis in Table III is not very encouraging as regards temperate climates, but the figures are averages, and there are many days on which the heat recovery could be two to three times as great as the average. The data collected on one such day are shown in Fig. 3, on page 377. Curve E_n shows the direct radiation on a normal surface, curves E_i the calculated direct radiation incident on the absorber, and the effective radiation intensity as measured by a recording thermopile, and the block diagram H_t shows the heat collected by the absorber at temperature t. The heat recovery on this day was quite satisfactory and gives a more optimistic impression of the possibilities of the direct use of solar energy in latitudes and climates where the air mass factor would be somewhat improved and the greatest handicap, the cloud factor, would be eliminated.

Basic Principles of Heat-Absorbing Systems.

Flat-Plate Absorbers.—The basic principle of this type of absorber may be illustrated by considering a flat metal plate exposed to solar radiation. Assuming a constant rate of incident radiation, the initial rate of heat collection will be a maximum when the plate is at atmospheric temperature and heat losses are negligible, and the temperature of the plate will rise until there is equilibrium between the incident radiant energy and the various forms of heat loss. If now a working fluid is circulated in thermal contact with the plate and heat thereby extracted, then the rate of heat collection will be a maximum when the rate of flow is such that the mean temperature of the working fluid is atmospheric and the temperature rise is very small, while at the equilibrium temperature no heat can be abstracted without causing a reduction in temperature.

Thus if H_t is the heat collected at a temperature t, with atmospheric temperature t_a and equilibrium temperature t_e, then the efficiency of collection will be a maximum as t tends to t_a and a minimum as t tends to t_e. The equilibrium temperature and the efficiency of collection at intermediate temperatures between t_a and t_e will be increased by improving the rate of absorption on the front surface of the metal plate and by reducing the heat losses. This can be effected by painting the front surface of the absorber dead black, by polishing the back surface and protecting it with heat-insulating material, and by covering the front of the plate with one or more sheets of glass.

TABLE III.

Month.	Air Mass Factor.	Attitude Factor.	Cloud Factor.	Overall Factor.	B.Th.U. Per Square Foot for 8 Hours.		
					Direct Radiation.	Diffuse Radiation.	Total Radiation.
January/December	0·30	0·72	0·15	0·032	110	98	208
February/November	0·41	0·76	0·15	0·047	162	111	273
March/October	0·53	0·82	0·16	0·070	241	220	461
April/September	0·57	0·86	0·33	0·162	557	377	934
May/August	0·60	0·87	0·36	0·188	647	405	1,052
June/July	0·63	0·86	0·34	0·184	633	467	1,100

The solar constant, assumed to be 430 B.Th.U. per square foot per hour, multiplied by the overall factor which is the product of the first three of the above factors, gives the direct incident radiation, to which must be added the appropriate diffuse radiation. The following two efficiencies must also be incorporated to allow for the characteristics of the absorbing system, namely:

Absorption efficiency, $\eta_a = \frac{H_t}{E_i}$, where H_t is the heat absorbed at temperature t and E_i is the effective rate of incident energy after allowing for the above factors.

Utilisation efficiency, η_u—the efficiency with which the heat collected is utilised. This depends upon the purpose of the installation, and would be quite high for direct utilisation of low-grade heat, but relatively low if the heat were used to drive some form of engine.

Each of these factors takes considerable toll of the initial solar constant, and as an example the figures in Table III have been computed for the latitude of London, the meteorological data being taken from records at Kew Observatory over the last 20 years. The calculations apply to a south-facing surface tilted at an angle of 40 deg. to the horizontal and operating over the period 8 to 16 hours local time.

The function of the glass plates covering the front of the absorber needs further explanation. Although the energy incident on the receiving metal surface is reduced by reflection and absorption at each glass plate, the reduction in the heat loss from the metal plate to the atmosphere exceeds the loss in transmission and there is a net gain in heat collected. The benefit is mainly due to the reduction in convection heat loss from the absorber surface, and for this purpose a second and even a third air space is an additional advantage, since the layer of air immediately in contact with the metal surface becomes highly heated. There is, in addition, a reduction in radiation loss from the metal surface, since glass is opaque to the long-wavelength radiation emitted.

The optimum number of glass plates depends upon the intensity of the incident radiation and the temperature of heat collection, the effect being shown by an analysis for a typical system in which the cooling loss H_c in B.Th.U. per square foot per hour is given by the following equation:—

$$H_c = c\,(t - t_a)^{1\cdot 2}, \qquad . \quad . \quad (8)$$

where the estimated values of c are: one glass plate

APPLICATIONS OF SOLAR ENERGY.

Fig. 5.

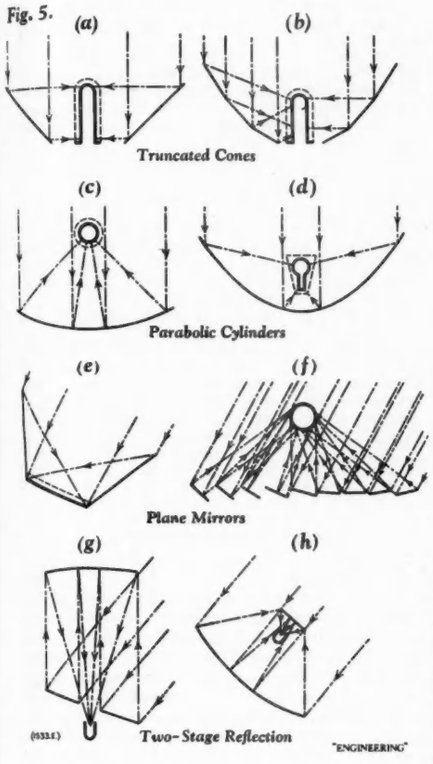


FIG. 6. SHUMAN-BOYS SOLAR BOILER AT MEADI, CAIRO.

$c = 0{\cdot}42$; two glass plates $c = 0{\cdot}30$, and three glass plates $c = 0{\cdot}22$.

Assuming the transmission coefficient for each glass plate to be 0·9, which is about the highest value possible, and if E_i is the rate of energy incident on the outer glass plate, then H_o, the heat collected at zero temperature rise, will be $0{\cdot}9\ E_i$ for one glass plate, $0{\cdot}81\ E_i$ for two plates, and $0{\cdot}73\ E_i$ for three plates. The additional heat lost by cooling at any given temperature of collection t may be calculated from the cooling loss equation above, using the appropriate value of c.

This treatment is somewhat simplified, for the thermal interaction between the glass plates is neglected, but it is sufficiently accurate to show the general trend. The series of curves in Fig. 4 show the rate of heat collection at different temperatures with various numbers of glass plates for two values of E_i, the incident radiation. An incident radiation of 300 B.Th.U. per square foot per hour is the highest value likely to be attained; 200 B.Th.U. per square foot per hour is a good average for bright sun conditions. At low temperature differences between absorber and atmosphere the smaller number of glass plates is preferable, but greater heat collection is obtained with the larger number of plates when the temperature difference is increased. It has generally been found that two glass plates are most satisfactory; the slight extra gain with three plates rarely warrants the additional expense.

The curves in Fig. 4 show the rate of collection at a definite temperature difference $t - t_a$. If the working fluid enters the absorber system at atmospheric temperature t_a and is raised to a final temperature t at exit, then the mean efficiency of collection will be greater than that at the final temperature t. The final temperature at which the heat is collected should not exceed the mean of the atmospheric and equilibrium temperatures, t_a and t_e, respectively, if an absorber efficiency of the order of 50 per cent. is to be attained.

With simple absorbers of the type described above a satisfactory heat yield is obtained at temperatures of the order 140 deg. to 160 deg. F., while even in Great Britain an equilibrium temperature of 300 deg. F. can be attained. It is usual to maintain the absorbers in a fixed position, as they will operate successfully, though at a reduced rate, up to an angle of solar incidence of 60 deg. This corresponds approximately to the period four hours before and after noon, and to utilise early morning or late evening sunshine it would be cheaper to provide separate absorbers rather than to complicate the construction by making them movable. The flat-plate absorber has been successfully applied in large numbers for providing domestic hot water in the southern states of the United States and there is no reason why they should not be equally successful in many parts of the world. A detailed analysis of the operation in England of such a heater is given later.

Heat Absorbers with Concentration by Mirrors.—Although the alchemists and early chemists used lenses to concentrate solar radiation for the heating of compounds in sealed glass vessels, mirrors constitute the only feasible system of concentration for the large-scale utilisation of solar energy. The period 1870 to 1915 was one of great activity in the development of such systems, and almost every possible arrangement of mirrors was devised and tested. All mirror systems must of necessity be guided to follow the apparent motion of the sun, and the higher the degree of concentration the more accurate must be the focusing.

The advantage of mirror concentration is that the area from which heat loss occurs is less than the area receiving radiant energy, and the heat losses are proportionately reduced with an increase in the equilibrium temperature. Let r be the concentration, defined as the ratio of the projected area of the mirrors to the area of the heat-absorbing surface. Then the rate at which energy is received at the absorber is $E_i\ r\ \eta_r$ where η_r is the efficiency of reflection. If the absorber is protected from convection loss by one sheet of glass, for which the transmission efficiency is η_t, then heat will be absorbed at the rate $E_i\ r\ \eta_r\ \eta_t$, and will be lost at the rate $c\,(t - t_a)^{1{\cdot}3}$. Putting $\eta_r = 0{\cdot}85$, $\eta_t = 0{\cdot}9$ and $c = 0{\cdot}42$ enables an estimate of the probable equilibrium temperatures to be calculated, assuming $t_a = 80$ deg. F. The figures for various degrees of concentration are given in Table IV, which also includes the equilibrium temperatures of flat-plate absorbers for comparison.

Assuming that the most effective working temperature is midway between the equilibrium and atmospheric temperatures, it is clearly quite possible to collect heat at temperatures sufficiently high for power generation and many other purposes. There are, however, many practical problems to be solved, the most important being that of designing a simple and robust framework for the mirrors which can be maintained in alignment with the direction of the sun. While this involves no difficulty in principle, it is essential to reduce the cost to a minimum. One feature in favour of solar mirrors as compared with telescope mirrors is that the former may be of tesselated construction, i.e., built up from a number of small plane mirrors, provided that the dimensions of each piece of mirror are less than the dimensions of the heat absorber upon which they direct the radiation.

TABLE IV.—*Equilibrium Temperatures in Deg. F. for Flat Plate and Mirror Absorbers. Atmospheric Temperature 80 deg. F.*

Type of Absorber.	Incident Radiation, B.Th.U. Per Square Foot Per Hour.	
	200	300
Flat plate—		
1 glass cover	186	225
2 glass covers	207	253
3 glass covers	228	282
Mirrors—		
Concentration 5	400	520
Concentration 10	630	830
Concentration 20	1,015	1,360

This section may be summarised by stating that mirror systems are essential for heat collection at high temperatures, but that the construction will inevitably be expensive and there are reflection losses. Also, since mirror systems have a small angle of view they do not collect the diffuse radiation which may form quite an appreciable proportion of the total radiation. The best policy would be to use flat-plate fixed absorbers of relatively simple construction for preliminary heating of the working fluid, and then to raise the temperature to the final value by mirror concentrating systems.

EXPERIMENTS WITH SOLAR-ENERGY UTILISATION, 1870-1912.

Some mention has already been made of early efforts to develop power from solar radiation, but it is little realised how much was accomplished in the period 1870 to 1912. The late Mr. A. S. E. Ackermann published an extensive account of these early developments,[3] giving many references which, as far as possible, have been studied in the original by the writer. A brief résumé of these experiments is given below, the dates showing the period during which the investigations were conducted.

Carl Güntner[4] (Austria, 1854 to 1873 approx.) experimented with solar boilers and mirror systems of the tilting type shown diagrammatically in Fig. 5 (*f*), but gave no records of large-scale results.

A. Mouchot[5] (France, 1860 to 1880) constructed conical mirrors of the type shown in Fig. 5 (*a*). Mirrors of 5 to 20 sq. m. area were used to generate steam at pressures up to several atmospheres which operated engines and water pumps. The

powers stated are misleading, as the actual pumping output was only a small fraction of a horse-power. The average thermal efficiency of the boiler was about 50 per cent. On September 29, 1878, steam was used to operate an ammonia-absorption refrigerator which had been invented by Carré about 1860, and this must have been the first occasion on which ice was produced by direct solar radiation.

A. Pifre[6] (France, 1878) modified Mouchot's mirror system, as shown diagrammatically in Fig. 5 (*b*), and claimed a boiler efficiency of 80 per cent.; the reflector area was 9·25 sq. m. This mirror, with steam engine and printing press, was demonstrated at the Exposition Universelle in Paris.

H. Bessemer[7] (England, 1868) constructed the solar furnace shown diagrammatically in Fig. 5 (*g*), the concave mirror being built from about 100 separate segments and having a diameter of 10 ft. Copper was melted in a crucible at the focus and zinc was vaporised, but Sir Henry Bessemer was disappointed with these results and discontinued the experiments after several years.

of these liquids was used to drive an engine. In their final design the trough area was 1,000 sq. ft. and the water was brought to a temperature of 180 deg. F. The heat was transferred to sulphur-dioxide liquid and the vapour used in an engine, which was stated at times to have developed 15 h.p., but this is much higher than the possible continuous rating of the plant.

Frank Shuman[12] (U.S.A., 1906). The first plant was similar to that of Willsie described above. The trough area was 1,200 sq. ft. and ether was used as the secondary fluid. The engine was stated to have developed 3·5 h.p., which is a reasonable efficiency. Experiments were continued until 1911, when Shuman decided to use low-pressure steam as the working fluid. The long fixed absorbers had a cross-section as shown in Fig. 5 (*e*), with a concentration ratio of 2. The total effective area was 10,296 sq. ft. and up to 816 lb. of low-pressure steam could be produced per hour. This corresponds to a boiler efficiency of about 30 per cent., based on incident radiation. The steam was used in a specially-designed low-pressure engine,

TABLE V.

Designer.	Location.	Concentration Ratio, *r*.	Evaporation, Lb. Per Square Foot Per Hour.	Thermal Efficiency of Boiler, Per Cent.	Square Foot Area Per H.P. Developed.
Ericsson	U.S.A. ..	9	0·17	60	100 (estimated)
Eneas	Pasadena, U.S.A.	13·5	0·17	75	70 (not possible)
Shuman (Ether)	U.S.A. ..	1·0	—	—	340
Shuman	Tacony, U.S.A.	2·0	0·08	30	570 (estimated)
Shuman and Boys	Cairo ..	4·6	0·12	40	695

John Ericsson[8] (U.S.A., 1864 to 1999), a prolific inventor, spent much of his time studying solar energy and its utilisation. He devised several types of radiometers, and determined a value for the solar constant in almost exact agreement with the present accepted value. Ericsson had a far clearer knowledge of thermodynamics than other workers, but unfortunately did not publish precise details of his inventions because of the fear of these being copied. He seems to have favoured parabolic cylindrical reflectors as shown diagrammatically in Fig. 5 (*c*), and used the heat either in steam or hot-air engines.

William Adams[9] (England, 1876) constructed a mirror-operated boiler with steam engine and pump at Bombay. Insufficient information was recorded to enable the power output to be determined. He also constructed a successful solar cooker.

J. Harding[10] (England, 1883) constructed apparatus for solar distillation of water in Chili. Impure water was contained in shallow troughs, which were covered with sloping glass plates on which the vapour condensed and ran into collecting troughs. The total area was 51,200 sq. ft. and output averaged 1 lb. of water per square foot per day, the water temperature in the troughs being 140 deg. to 150 deg. F.

C. L. A. Tellier (France, 1884) wrote books on the problems of utilising solar energy, and apparently had considerable knowledge of the subject, but no records of experiments can be found.

A. G. Eneas (U.S.A., 1900) constructed several solar boilers with a conical-mirror system, as in Fig. 5 (*a*). The most famous, of which a photograph is often used to illustrate the theme of solar power, was erected at the Ostrich Farm, Pasadena, the outer rim of the mirror being 33 ft. 6 in. in diameter and the inner rim 15 ft. in diameter.[11] Steam was generated at 150 lb. per square inch pressure and used to drive an engine, for which 10 to 15 h.p. was claimed. As the effective area of the mirror was 705 sq. ft. the overall thermal efficiency based on the maximum possible incident radiation is 12 per cent. for 10 h.p. developed. This is somewhat higher than is likely to have been attained, but there is no doubt that the general arrangement was very effective.

H. E. Willsie and J. Boyle (U.S.A., 1902) were the first to use a two-fluid system with a volatile liquid. Radiation was absorbed in a horizontal trough of water, glass-covered, in which the pipes containing liquid ammonia, ether, or sulphur dioxide were immersed. The vapour from one

and Ackermann estimates that an average of about 18 h.p. could have been developed over 5 hours, though precise measurements were not made. The company with which Shuman was associated engaged Sir Charles Boys as a consultant for the design of a very large power plant which was erected near Cairo in 1912. Parabolic mirrors were adopted, as shown in Fig. 5 (*d*) and in the photograph reproduced in Fig. 6. Each of the five mirror frames measured 14 ft. across by 205 ft. in length, giving a total effective collecting area of 13,752 sq. ft. The steam, produced at approximately atmospheric pressure, was used to drive the low-pressure engine mentioned above. This was used to pump water, but the pumping horse-power was less than 20. This low figure was attributed largely to faults in the pump, and it was estimated that 50 brake horse-power should have been developed. The war of 1914 undoubtedly stopped the work at this installation, otherwise it is probable that many of the faults in design would have been rectified. The estimated efficiency of the boiler was 40 per cent., based on incident radiation.

Dr. C. G. Abbot,[13] for many years secretary of the Smithsonian Institution, has devoted much of his life's work to investigations on the physics of solar radiation, particularly the determination of the solar constant and the spectral distribution of solar radiation. He has also constructed small-scale units for the production of steam power, for water distillation and for cooking, showing that all these could be accomplished if the economical conditions were favourable.

To summarise this section, very few of the solar-power installations have been tested in a manner which would be considered satisfactory by modern standards. Nearly always "something went wrong," but Table V gives a summary of the characteristics as nearly as these can be deduced. The figures show a large variation, chiefly because powers were measured for short periods only, and in some cases heat storage was being utilised to give a higher power for a short period than could have been maintained continuously. Assuming that the maximum incident radiation is 300 B.Th.U. per square foot per hour, then with an overall thermal efficiency of 5 per cent. the requirement is 170 sq. ft. of projected mirror surface per horse-power. It will not be easy to obtain higher efficiencies than this with small engines, but with improved equipment a figure of 100 sq. ft. per horse-power may be anticipated.

(To be continued.)

REFERENCES

[1] Evans, D. S., "The Physics of the Sun," *Discovery* vol. 7, pages 168, 204 and 234 (1946).

[2] Moon, Parry. "Proposed Standard Solar-Radiation Curves for Engineering Use," *Jl. Franklin Inst.*, vol. 230, page 583 (1940).

[3] Ackermann, A. S. E., "The Utilisation of Solar Energy," *Jl. Roy. Soc. Arts*, vol. 63, page 537 (1915).

[4] Güntner, Carl, "The Utilisation of Solar Heat for Industrial Purposes by Means of a New Plane Mirror Reflector," *Scientific American Supplement* No. 1586, vol. 61, page 25409 (1906).

[5] Mouchot, A., *Comptes Rendus*, vol. 86, page 1019 (1878); vol. 87, page 481 (1878); vol. 90, page 1212 (1880); vol. 94, page 943 (1882).

[6] Pifre, A., *Comptes Rendus*, vol. 91, page 388 (1880); *Nature*, vol. 26, page 503 (1882).

[7] Bessemer, H., *An Autobiography*, London, 1905, page 354.

[8] Ericsson, John, "Contributions to the Centennial Exhibition," New York, 1876.

[9] Adams, W., "Cooking by Solar Heat," *Scientific American*, vol. 38, page 376 (1878).

[10] Harding, J., "Apparatus for Solar Distillation," *Proc. Inst. C.E.*, vol. 73, page 284 (1883).

[11] Holder, C. F., "Solar Motors," *Scientific American*, vol. 84 (New Series), page 169 (1901).

[12] Ackermann, A. S. E., "The Utilisation of Solar Energy," *Trans. Soc. of Engineers*, for 1914, page 81.

[13] Abbot, C. G., "Utilising Heat from the Sun," *Smithsonian Misc. Collections*, vol. 98, No. 5 (1939); "Solar Radiation as a Power Source," *Smithsonian Report* for 1943, page 99.

CENSUS OF PRODUCTION FOR 1954.

In a preliminary notice issued by the Board of Trade, it is stated that the scope of the census of production to be taken in 1955, in respect of the year 1954 and the information to be obtained, have now been considered by the Census of Production Advisory Committee. It has been decided that all establishments within the field of production, and taken into account in the censuses for 1951, 1952 and 1953, will be included in the 1954 census, which will be on lines similar to those of the full census for 1951. The statutory form of return will include questions on working proprietors, the number of employees, wages and salaries, the capital expenditure on plant and machinery, and also on vehicles, capital expenditure on new building work, materials and fuel purchased, the work given out, stocks at the beginning and end of the year, output data, and transport payments. Most of the questions will be broadly the same as for the 1951 census. In the wages and salaries section, however, firms will be asked to give information concerning the employers' payments to superannuation and other pension funds, as well as their contributions to all National Insurance schemes. This, it is pointed out, will help to complete the information available relating to labour costs. In the materials and fuel section, firms will be asked to state, as in the 1948 census, the total cost of materials and fuel purchased with details, by quantity and value, of the principal items obtained. Moreover, information will be sought regarding certain materials which are common to virtually all trades, such as replacement parts and packing materials. In the output section, firms will be requested to show the total value of the sales and work done, and to give information on the sales of each of a number of products, on the lines of the detailed form used for the 1951 census. Particulars regarding the output and materials headings, which are to be specified for 1954, will be sent for comment to the trade associations concerned as soon as possible, but firms requiring further information concerning the census for 1954 should address their inquiries to the Census of Production Office, Neville House, Page-street, London, S.W.1, stating the nature of the business carried on.

NEW LOUD-SPEAKING TELEPHONE.—Winston Electronics, Hampton Hill, Middlesex, have introduced a loud-speaking telephone which is designed to operate from a single-phase supply. The microphone is extremely sensitive and ample volume is obtainable from the loudspeaker. The equipment automatically adjusts itself to the line conditions and the channel switching is instantaneous. Selective calling by lever switches and a full dialling system are incorporated.

MAGNETIC RECORDING FOR BROADCASTING.

ABOUT 60 per cent. of the British Broadcasting Corporation's requirements for recording programmes for broadcasting are met by the use of a magnetic tape system and the remainder by discs. This proportion will, however, be changed when a scheme involving the installation of some 180 new tape recording and reproducing machines has been completed. Magnetic tape recording depends on the use of a plastic tape, ¼ in. wide, which is impregnated or coated with iron oxide. It provides high-quality reproduction, while the recorded material can be erased and the tape used again. It lends itself to precise editing and, being lighter and less vulnerable to mechanical shocks than discs, is particularly suitable for mobile work. On the other hand, the recordings tend to deteriorate with time and may be accidentally erased if they are brought close to a powerful magnet. Disc recordings are therefore always used when programmes are to be kept for historical purposes and are also essential when immediate "playback" and quick editing are required. The majority of the recordings sent abroad by the Corporation's Transcription Service are therefore of this type.

The new tape recording machines are of four basic patterns: static, for permanent installation in studio centres; mobile, for use in recording cars; midget portable equipment which can be carried and operated by a reporter; and rehearsal and training equipment. The midget recorders measure 15½ in. by 7½ in. by 8¼ in. and weigh only 14½ lb., including the batteries. They are suitable for recording speech and are being sent to broadcasting centres throughout the United Kingdom and to the Corporation's foreign news correspondents overseas.

The speed at which the tape runs past the recording and reproducing heads is important and must obviously be standardised if the recordings are to be interchangeable. A high tape speed is necessary if first-class qualitity of reproduction is to be obtained, but obviously the higher the speed the shorter the playing time obtainable with a single reel of tape. On the earlier machines the tape speed was 30 in. per second, but improvements in design and material have enabled this to be reduced to 15 in. per second without any decrease in quality. Speeds of 7½ in. and 3¾ in. per second are also used. On static machines, operating at 30 in. or 15 in. per second, a reel holding 2,400 ft. of tape is employed, giving a playing time of 30 minutes at the latter speed. On the midget recorders the reels hold 600 ft. of tape.

The recording equipment described is being supplied by Electric and Musical Industries, Limited, Hayes, Middlesex, the Radio Gramophone Development Company, Limited, East Molesley, Surrey, and the British Ferrograph Recorder Company, Limited, 138, Sloane-street, London, S.W.1. It is hoped to complete the installation by the end of the present year.

FITTINGS FOR FLEXIBLE HOSE.—It is announced that Super Oil Seals & Gaskets, Ltd., Factory Centre, King's Norton, Birmingham, 30, now hold the licence for "Aeroquip" detachable re-usable hose fittings. These fittings consist of an outer casing nut and an inner nipple which between them grip the end of the rubber, or synthetic-rubber, hose. A union nut on the nipple completes the fitting. They are convenient when odd lengths of hose have to be made up and, since they can be used again when a length is scrapped, they are economical.

THE LATE MR. R. C. WALKER.—We regret to record the death of Mr. Ronald Claude Walker, which occurred on Friday, August 7, at the age of 57. Mr. Walker received his technical education at Reading University and joined the technical staff of the Osram-G.E.C. Lamp Works in 1925. He was transferred to the G.E.C.-Osram Valve and Electronics Department three years later and was subsequently in charge of the technical and commercial development in that organisation of photocells, Geiger-Müller counter tubes and special electronic devices. He was elected an associate member of the Institution of Mechanical Engineers in 1934 and of the Institution of Electrical Engineers in the same year. He was the author of a book on "Electronic Equipment and Accessories."

ENGINEERING IN THE NEXT TWO THOUSAND YEARS.*

By LORD DUDLEY GORDON.

THIS is only the second occasion on which I have attended the annual meeting of the British Association for the Advancement of Science. The former occasion was as far back as 1897, when the annual meeting was held in Toronto, and my most vivid recollection of it is of a paper by Professor Roberts-Austen on "Molecular Movements in Metals." Certain points were demonstrated by the melting of metals in a small electric-arc furnace consisting of a crucible or porcelain bowl over which an electric arc was formed between two carbon electrodes. Lord Kelvin was present during the reading of this paper and I remember my youthful amazement when, at the end of the paper, he asked some questions of the operator of the furnace, whose name was Stansfield, as to exactly how it worked. I imagined that the great man possessed such a store of knowledge on all scientific subjects that it would be unnecessary for him to ask questions about anything from anyone.

In 1951, Sir Claude Gibb gave his presidential address on the past 2,000 years of engineering. I will make an attempt to look forward instead of backward, and to suggest some thoughts of how the science and practice of engineering may develop in future years. It is perhaps appropriate to do so at the present time because, up to quite recent years, the energy from which the production of power has been derived has been mainly from heat created by the combustion of material found in the earth—wood or coal or oil. The obvious exceptions are the production of power from water falling from a high level to a lower level, which is using the force of gravity, or from wind, which is the result of atmospheric changes.

The energy made available by the combustion of coal has only been turned into useful work as the result of the construction of apparatus which, in its turn, has depended upon other minerals taken out of the earth. In the early days of the development of the industrial era, no particular care was taken to preserve such resources, because, with the rate of demand which existed at that time, they appeared to be virtually inexhaustible; but in more recent years it has been realised that, at the present rate of progress, there is a limit to these supplies. This has resulted in careful investigations being made into the reserves which remain, notably the report by the Materials Policy Commission of the United States, appointed by the President to consider "resources for freedom," known as the Paley Report.

This report obviously deals with the matter from the point of view of the resources available in parts of the world not covered by the Communist bloc, and does not look farther forward than the next 25 years. Even over this comparatively short period, the report comments, detailed estimates are beyond the capacity of even the most electronic intelligence. This fog of the future is even more mysterious when it is realised that to-day, less than 10 per cent. of the population of the world is consuming half the volume of the materials now being produced from the Earth's surface. A striking example is the inroads made on the Precambrian ores in the Lake Superior area, where two-thirds of the known supply has already been exhausted. This is coupled with the thought that these deposits are the result of what took place as long ago as a thousand million years and that no replacement is possible. This problem of replacement does not yet apply to timber; it is suggested, for instance, that the Bowater pulp mills in Newfoundland can continue indefinitely at the present rate of output, because timber is not being felled at a rate greater than its replacement by new growth.

Minerals which are being mined to-day are from deposits which are reasonably accessible, but the knowledge that they are not inexhaustible has naturally led to prospecting in less accessible parts of the earth's surface. From present knowledge it would appear that these further deposits add greatly to the estimated period during which such supplies will be available for the use of man, but the cost of the necessary development and the transport of minerals to the point where they are made use of will increase considerably.

Estimates of the length of time that will be taken to exhaust the present resources of coal, which still remains the greatest source for the production of heat, vary as between different parts of the world. The Paley Report estimates, for instance, that, at the present rate of consumption, the United States coal resources are good for another 2,500 years, whereas estimates for the coalfields in Great Britain are limited to something like 250 years only; some estimates, indeed, are as low as 150 years. This assumes that the increase in the rate of consumption will not ascend even more steeply than it is doing at the present time.

The most important alternative to the use of coal for the production of heat is oil, and petroleum products generally. Here the estimates of reserves available vary more greatly than those for coal, probably because new sources of oil are constantly being discovered and developed, whereas this does not apply to coal to any great extent. The Paley Report suggests that the present known sources in the free world may be exhausted within a generation. This estimate would not be affected by the addition of the resources available in Communist-controlled countries, which are unlikely to become exporters because they can do no more than meet their own requirements.

These estimates probably ignore resources which may exist beneath the bed of the oceans. These would have to be developed on the same lines as the deposits already being worked under the sea in the Gulf of Mexico, but even if these deposits do exist, new methods of exploitation would have to be devised at a greatly increased cost. The possibilities of this source of oil are discussed in Miss Rachael Carson's book, *The Sea Around Us*.

The other obvious source of fuel is natural gas, developed on the lines already in use in Canada and in Italy. It does not appear that this source will make any considerable contribution to world sources of heat over the long period under consideration. Sources such as peat and oil shale, over this period, are probably not worth considering.

So much thought is given to-day to the possibility of development of nuclear energy, that less anxiety exists about the question of fuel supplies than would otherwise be the case; but, at the present stage of development, materials such as uranium have to be found and are at present being sought all over the world. This is an interesting example of how material for which there is no important known use in one generation may be in great demand in another. Fifty years ago, uranium, by virtue of its close similarity to tungsten, was noted as a possible alloy to be used in tool steel, but not much progress was made. To-day, we find the somewhat dramatic development of the creation of Uranium City and Port Radium in Canada—the former, I believe, largely constituted from materials moved from the former town of Goldfields.

In South Africa, the gold-mining industry is paying a great deal of attention to the recovery of uranium, which, until recent years, would have been looked upon as not worth extracting from tailings dumps, even if its presence had been realised. The strength of the South African position is that it is worth while to work the mines for the gold alone. Gold is in a quite exceptional position compared with any other metal because it is a basic medium in the exchange of currencies, and no completely satisfactory alternative has been devised. The mining of gold for its own sake is therefore likely to continue for a very long period, and uranium from this source can be obtained without the heavy overhead expenditure involved when it has to be extracted for its own value only.

It would be quite inappropriate in a presidential address making this wide survey to attempt to discuss the details of possible developments in nuclear energy. It is sufficient to say that, so far as we have gone at present, progress has been made in the direction of producing heat which is

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* Presidential address to Section G (Engineering) of the British Association delivered in Liverpool on Thursday, September 3, 1953. Abridged.

made use of to create power as an alternative to combustion of fuels, and is used in the form of normal heat engines. Maybe there will come some development by which nuclear energy could be employed directly, by the use of apparatus not yet thought of.

At present, the development of nuclear energy appears to be based on the availability of uranium and possibly thorium, which come from resources which, at the present rate of consumption, may well be exhausted before the period of 2,000 years. There is, however, the thought that, by a process of reaction, there may be a type of reproduction, the so-called breeder piles, which would greatly reduce the amount of uranium required and so extend the life of the discoverable resources. It may not be outside the bounds of possibility that, in the course of development, some alternative method of producing nuclear energy might be evolved which would displace the use of uranium.

An example of the expectations which are raised by the present progress towards the development of nuclear energy is well indicated by the suggestion, made some months ago, that the coal industry would be prudent to assume that, before long, the production of power from nuclear energy will be no more costly than coal; and, for this reason, research should immediately be undertaken with a view to finding an output for surplus coal. On the other hand, it has been suggested by Sir Charles Darwin in his book, *The Next Million Years*, that the amount of uranium at present in the earth is such that, if it is to remain the only source from which nuclear energy can be produced, it is unlikely to be as much as can and will come from coal. It is unlikely to be ten times as much and certainly will not be a thousand times as much; so that, if this assumption is correct, the supply would be exhausted well within the period of 2,000 years which is under discussion.

The use of the so-called hydrogen bomb as a destructive agent has already received some attention, but just as fire, first used for cooking and warming and then as a destructive agent, was later harnessed for the production of power, so it is possible that the almost unlimited amount of hydrogen recoverable from the air or the sea might be used as a source of power. Sir Charles Darwin's book, indeed, expresses the hope that it will never be possible to release all the ordinary hydrogen in the earth because it might well involve the destruction of our planet. But there may be hopes of successful use of heavy hydrogen as a fuel.

Sources of power which do not depend on the creation of heat by combustion are obviously water power and wind. The attraction of these sources of power is that it is difficult to conceive that they could be exhausted within the next 2,000 years, though there would presumably come a time much sooner than that when all the possible sources of hydraulic energy had been developed. This will surely some day include the use of energy derived from ocean tides. Here is an immense source of power which is inexhaustible. Professor J. B. S. Haldane, however, has sounded a warning that the final result of unlimited development of tidal power would be to increase the braking action of tides very considerably, so that the rotation of the Earth would slow down and the day would become longer. The moon would again begin to approach the Earth and the final result would be the destruction of this planet; but as he calculates that this final judgment is not likely to take place before A.D. 36 million, we need not be greatly concerned about it as a deterrent during the next 2,000 years.

Experiments for the production of power from wind are already being undertaken, but in this case it would appear that the constant variations in the amount and velocity of movement of air in any given spot are so great that we cannot yet see how a large and constantly available source of power could be developed.

No attempt has yet been made to use the heat available in the inner part of this planet. There are from time to time spectacular demonstrations in the form of volcanic eruptions which give an indication of the immense resources available. These would have to be tapped by some form of excessively deep boreholes and controlled by some means not yet thought of. The danger to be avoided is obviously the release of forces which would cause some terrible catastrophe similar to the destruction of Krakatoa in 1883. There remains solar energy as a possible source of power, but again limited as to location and magnitude: a subject on which Dr. A. Parker, of the Fuel Research Station, gave a most interesting paper more than two years ago.

Generation of electricity from water power, wind, tides or solar energy can be undertaken only in those places where Nature has made such sources of energy readily and constantly available. If they are to be made of general use, they will depend on the transmission of power over great distances. Progress has already been made in this direction by the transmission of electricity in the form of direct current at high voltages, but such means of transmission must always be very costly, not only from the point of view of the original installation, but also as a result of the high charges for maintenance. This difficulty would be overcome if some form of "wireless" power transmission could be devised. These intermittent sources of power will become more valuable when some means is found for the large-scale storage of electricity.

It seems certain that, in future years, the progress of engineering science will be more rapid than it was in the Nineteenth Century, for the reason that so much knowledge has been accumulated and that certain principles are so well established that they can no longer be doubted. I refer, for example, to the laws of thermodynamics, including acceptance of the Carnot principle, as well as to the gas laws of Boyle and Charles. The properties of steam at temperatures and pressures well beyond those in present use are well established, while in another direction we are now at home in the field of sub-zero temperatures. By parallel improvements in instrumentation also, the efficiencies of engines, machines and structures can be more closely studied, with advantate to the economy of constructional materials and of fuel.

There may be other sources of power which are as yet unexplored. I will venture to suggest that the force of gravity may some day be used as a source of power. It is used to-day indirectly in water-power generation of energy, but if we can learn how to control the force of gravity itself great developments would follow. If it could be controlled or even generated, and its intensity and direction varied at will, it could be used for many purposes, particularly for travel. This suggestion is obviously quite visionary. Knowledge to-day regarding gravitation is slight. It is true that the latest mathematical efforts have led Einstein and others to believe in a connection, rather than a mere similarity, between gravitation and magnetic force. No physical meaning to these equations has yet been found and it is possible that, as knowledge increases, it may be found that there is no hope of the control of this force by the inventions of man.

One of the most important results to mankind, in the development of the science of engineering, is the increase in the ease of movement from one part of the world to another. It was not very long after the introduction of the steam engine that it was applied to travel by means of railways and steamships. The same can be said of internal-combustion engines and, to a lesser degree, of the steam turbine, which has been applied for travel purposes so far almost exclusively to ship propulsion, though there have been examples of steam-turbine locomotives.

The increased speed and range of travel which the development of science can provide has always been a favourite subject of the novelist who makes the future his theme. Jules Verne not only imagined beforehand with considerable accuracy the development of the submarine, but also in his novel, *The Clipper of the Clouds*, describes something similar to the present-day helicopter. H. G. Wells in his novel, *The War in the Air*, was not quite so accurate in his forecast, since he visualised the dirigible airship as possessing greater striking power in war than the aeroplane.

Most of these forecasts assume the use of forces which were well known at the time of writing. Jules Verne, for instance, in his *Voyage to the Moon*, imagined a projectile propelled by the explosion of gunpowder in a cannon composed of a vertical bore in a mountain. In the same way to-day, proposals for inter-planetary travel assume the use of rocket propulsion on the basis of developments now taking place; but the control of the force of gravity, if it could be achieved, would not only make the return journey more feasible, but would overcome the disadvantages of the varying forces of gravity during the journey and on arrival at planets which, being smaller, have a lower force of gravity than our own.

Another alternative source of power is the use of some chemical action not yet perfectly understood. Working on the principle of thermodynamics, engineers attempt to design a prime mover which will use the highest possible temperature of the agent selected and collect the energy which is given off as that agent is reduced to the lowest possible temperature; but in the case of the human or other animal body which exerts power, there is no corresponding absorption of an agent at high temperature, rejected at a lower temperature. In the human body, energy appears to be accumulated in the form of food, particularly carbohydrates, without any appreciable rise in temperature; and when doing work such as turning the handle of a winch or hauling on a rope, no appreciable drop in temperature takes place. When thinking of a period as long as 2,000 years, is it unreasonable to suggest that a source of power based on a more or less isothermal chemical reaction may be evolved?

So far as the immediate future is concerned, it appears to be certain that, with regard to mechanical engineering, power units will become almost exclusively those giving power by rotating rather than reciprocating motion. The first known prime mover making use of steam is generally accepted to be the classical reaction turbine of Hero, but when the steam engine began to be developed as a practical working unit in the latter part of the Eighteenth Century, the reciprocating motion was the one generally employed. Both steam and internal-combustion engines were developed on these lines, though the greater part of the power they developed was applied through flywheels and pulleys to a rotating motion, the obvious exception being the use of reciprocating pumps and compressors driven either by coupling through the crankshaft or directly by tail-rod drives.

Steam power was first used on a considerable scale for pumping water, which had for a long time been achieved by the plunger type of pump, the power being provided by men or by horses. This may have influenced the lines on which the steam engine was developed, but designers and constructors were limited by the materials then available.

The generation of electricity and the use of electrical power has always been developed through rotating generators and electric motors. It was, therefore, a natural step forward that the prime mover should also be rotating, in the form of either steam or gas turbines. The application of power by rotational movement has long been known in the case of centrifugal pumps and other similar apparatus, and in recent years there has been considerable development of turbine compressors for various uses, mainly for the larger sizes. The replacement of the immense blowing engines associated with the early days of blast furnaces, which are to-day superseded by rotary blowers, is an example. There is every indication that, before long, this will apply to smaller sizes as well. Gas turbines and jet propulsion for aircraft are already accepted almost as normal, and a beginning has been made with similar propulsion for motor cars and ships. It seems, therefore, quite reasonable to suppose that, certainly within the next 50 years, reciprocating motion will become the exception rather than the rule. Turbines and compressors tend to adopt constantly increasing speeds and higher temperatures, so that the weight and space occupied are constantly being reduced.

Great attention is being paid to-day to increasing the speed and range of air travel and it is confidently expected that long-distance travel at supersonic speeds will become common practice within the next 30 years or so. No less an authority than Sir Frederick Handley Page has suggested that the

next increase in speed, when it does come, will be in the form of a considerable jump to something like 900 miles an hour, and even higher speeds are evidently being considered. If such advances are to take place, it would seem essential that they should be accompanied by some means of reducing greatly the take-off and landing speed of aircraft, not only from the point of view of safety, but also with a view to reducing the size of airfields and the monstrously long runways which high speeds demand. This would also have the advantage of making it possible to construct airports closer to the great centres of population.

The problem of the reduction in the noise created by aircraft will surely one day be solved, as it has been so successfully in the case of motor cars. Indeed, when supersonic speed in level flight becomes the general rule, some means for the elimination of noise will become a vital necessity.

Now all these advances in the science and practice of engineering are the result, first of all, of the accumulation of knowledge as the outcome of the achievements of the past; but the result of improvements in design and practice can only be made use of as a result of the materials which become available. These new or improved materials again are the result of the accumulation of knowledge being constantly added to by research, and it all goes back to the availability of the mineral resources which came into being millions of years before man was ready to make use of them and are now being so rapidly exhausted.

Whatever new sources of power may be developed, they can be made use of only by power-producing units which are made of materials that have to be extracted from the Earth's surface, or produced in some other way. The power is transmitted to machines in factories which are constructed of much the same materials. The machines in the factories produce goods which again are made of the same materials, all taken from the Earth's surface. To-day, we think mainly of iron and steel products, though the use of other metals and plastics is becoming more and more familiar.

This leads quite naturally to the consideration of how long existing sources of supply for fuel and minerals are likely to last as demands increase, and what is to take their place when these supplies are eventually exhausted.

The use of iron and steel products, not merely for engineering apparatus, buildings and similar capital goods, but also for consumer goods, is so universal that it seems quite reasonable to measure the standard of living by the consumption of iron and steel and its final products per head of population.

Apparent Consumption of Steel per Head (in Ingot-lb.)

—	Average, 1937/38.	1948.	1950.	1951.	1952.
United States ..	641	1,131	1,237	1,343	1,138
Canada	346	623	614	793	737
Sweden	482	625	645	715	—
Australia (*a*)	428	415	538	643	—
United Kingdom (*b*)	495	614	630	642	706
Germany (*c*) ..	596	273	469	497	654
Belgium-Luxembourg	353	757	501	488	527
Netherlands ..	333	326	370	428	—
France (*d*)	289	408	332	407	518
Italy	123	110	141	166	—

(*a*) Year ended June 30. (*b*) Adjusted for stock changes. (*c*) Includes Saar, 1937-38; West Germany only, 1948-52. (*d*) Includes Saar, 1948-52.

The accompanying Table compares estimates of steel consumption per head in various countries (based upon ingot production less direct exports, ignoring "indirect exports" of steel in metal goods). It illustrates the point made in the report of the Productivity Team representing the Iron and Steel Industry which visited the United States in 1951: "It may be said without exaggeration that the American way of life manifests itself in a material sense primarily in the form of goods containing steel."

The Table is a clear indication that, with improved standards of living, for which every country in the world is striving, there must be increased consumption of steel per head for as long as the available sources of raw materials make it possible to meet the demand. The Table also indicates that the increase is directly related to improved standards: that is to say, those countries in which productivity is known to be low, lag far behind those countries with high productivity.

There seems no reason to suppose that this tendency to increased consumption of steel will diminish during the next few hundred years. It is reasonable to expect that the standard of living will be gradually raised throughout the world and that, even if the present rate of increase in population does not continue as rapidly as it is now doing, the total demand will continue to increase.

There are, therefore, two problems which have to be solved—first, the provision of sufficient power to meet world demands, and, secondly, the supply of materials which will make the application of that power useful to mankind; and it is the science of engineering which will be mainly responsible for solving these problems after the possible solutions have been indicated as the result of research. There is every indication that iron and steel products will continue to be the main source of supply, certainly for the next few hundred years, and there is still great scope for development in the production of iron and steel in the direction of improved composition and structure of metals so that the same results can be achieved with a much smaller weight of material. It has been suggested, for instance, that structural steel, if more completely homogeneous, could be so greatly increased in strength that the framework of a steel building might present the appearance of a spider-web construction compared to what we are accustomed to see to-day.

Now of even greater importance to the future of mankind than the necessary supply of materials to provide all the equipment which, though starting as a luxury, becomes a necessity as the standard of living increases, is the provision of sufficient food, which again is in greater demand as the standard of living increases.

Sir Charles Darwin in his book, to which I have referred, has some interesting thoughts on this subject. Certainly, there has been noted the tendency for the rate of increase of population to decrease with an increased standard of living, but even so it seems not unreasonable to assume that the population of the world may double itself in a century. This leads to the interesting conclusion that in 2,000 years the population would have increased a million fold and would require a million times the amount of food at present being produced in the world. It is difficult to imagine that this could be achieved, and long before the period of 2,000 years is exhausted there would be a constant struggle to provide by some means or another sufficient food to feed the population. This problem is already beginning to manifest itself, and, at all events in this country, we have become so much accustomed to rationing that it is held as a great achievement when the controls which go with rationing are removed.

Agricultural science is constantly showing how both vegetable and meat supplies of food can be increased, but these methods, in almost every case, bring engineering into play to provide the solution. One possible means of increasing agricultural resources is the irrigation of deserts, which up till now, has been achieved by diverting water from river systems. It is possible that future developments might take the form of converting sea water into fresh water by means of condensation or some other mechanical contrivance on a scale far larger than any method now in use and, by a great development of civil engineering combined with afforestation, irrigating vast areas such as the Sahara and making them available for agriculture.

Broadly speaking, it may be said that up till now agriculture has been possible in those regions of the earth where water, evaporated from the ocean and passed in the form of clouds to the land, is precipitated in the form of rain; and one of the functions of engineering in the future may be to reproduce that action by mechanical means, so that the effect of what would be the equivalent of controlled rainfall could be applied to any section of the Earth's surface.

Mention of the sea as a source from which the demands of man can be met makes one turn to some of the suggestions made by Miss Rachael Carson in her book, previously referred to. Hitherto the sources for the creation of power, and its use in the production of materials and finished goods for the use of man, have been sought almost entirely from the dry land, but it is suggested that the ocean is the Earth's greatest storehouse of minerals. Apart from the estimated resources of reserves of fuels in the earth, estimates have been made of the reserves of the more important metals, in addition to iron ore. Manganese ore does not appear at the present time to have any great economic reserves, but the Paley Report suggests that improved mining methods can be expected to meet the demand for many years to come. Aluminium, as at present produced, depends on supplies of bauxite, provided that there is an ample supply of electricity at a low price, which has led to the development of hydro-electric power for this purpose. No doubt it will be necessary in later centuries to devise some other means of producing aluminium.

The Paley Report attaches the words "reserves inadequate" for many metals such as chromium, copper, zinc, lead, nickel and tungsten. These are only examples, but it must be remembered that this report refers mainly to the next 25 years, and so it seems certain that more and more attention will have to be paid to the resources available from the sea.

Two important materials are already obtained in large quantities from the sea. In the case of magnesium, it is estimated that four million tons of magnesium are normally present in each cubic mile of sea water. Magnesium is already being extracted from the sea in commercial quantities in Great Britain and may be expected, as development continues, to provide structures of greatly increased strength and reduced weight as compared with what is available to-day.

The other important material already being obtained from the sea is iodine. In *The Sea Around Us* it is referred to as "the most mysterious of all substances in the sea."

I have tried to indicate some of the problems which will have to be solved by engineers in the space of 2,000 years. It seems reasonable to assume that we have reached a stage in the development of scientific knowledge which can form a basis for future advance with a diminishing reliance on the principle of trial and error. Thus advances will be made as the result of working out methods of which the final conclusion can be predicted with reasonable accuracy if only materials with the necessary characteristics to make use of the new methods can be produced. It would seem, therefore, that the present generation can feel that it has not merely a great opportunity, but a great responsibility, to start now to develop methods which will make it possible for the progress of man to continue when the resources at present available have become exhausted. Failure to commence development on these lines within the next 50 or 100 years would mean that life on this planet within 2,000 years might well deteriorate to a level much lower than that existing to-day.

ALUMINIUM FACING PANELS FOR SKYSCRAPER.—A 26-storey building at 99, Park-avenue, New York, U.S.A., now nearing completion, has been faced entirely with pre-fabricated aluminium panels. Each panel is two storeys in height with openings for four windows. By the use of this method, exceptional speed in construction was achieved, the placing and bolting into position of the panels, with a total surface area of 98,000 sq. ft., being completed in 66 working hours.

DAMAGE TO WOODEN LIGHTSHIP.—The oak-timbered English and Welsh Grounds lightship, stationed in the Bristol Channel, has been towed into Barry for temporary repairs before being taken to Swansea where she is likely to be broken up. She sustained much buffeting in rough seas on August 24 and sprang a leak. The pumps of the lightship, built in the middle of last century, could not cope with the volume of water and the Barry lifeboat stood by all night. She was towed to Barry, with pumps still working, for temporary caulking repairs in dry dock.

NOTES ON NEW BOOKS.

Sound: A Physical Text-Book.

By DR. E. G. RICHARDSON. Fifth edition. Edward Arnold and Company, 41, Maddox-street, London, W.1. [Price 25*s.*]

FIRST published in 1927, this well-known text-book is now in its fifth edition. Little alteration has been necessary in the earlier part of the book, which covers the classical aspects of sound, and the headings of the first nine chapters are the same as in the fourth edition. Additions include recent work on the influence of material and varnish on violin tone, on musical bubbles and edge tones. The title of Chapter X has been changed from "Supersonics" to "Ultrasonics" as recommended in the American Standard Acoustical Terminology (1951); the references might have included the author's own *Ultrasonic Physics*. Chapter XI, on subjective sound, is mainly concerned with speech and hearing. There is no entry under "speech" in the index and no mention of the remarkable method of visible speech display developed, within the past ten years, by R. K. Potter and his associates at the Bell Telephone Laboratories. Chapter XII of the previous edition has been expanded into three chapters. The first of these deals with the acoustics of buildings and corrects an error that had persisted through the previous four editions by providing a proper derivation of the amount of energy falling per second on unit area of the surfaces bounding an enclosure within which the sound energy is completely diffused. The Sabine reverberation formula alone is deduced; the more recent modifications of the reverberation formula are not mentioned. The following chapter, on terrestrial sound and signalling, considers the factors affecting sound transmission through the atmosphere and under water, with applications to sound-ranging and echo-sounding. The final chapter, on the reproduction and synthesis of sound, includes a section on electric musical instruments.

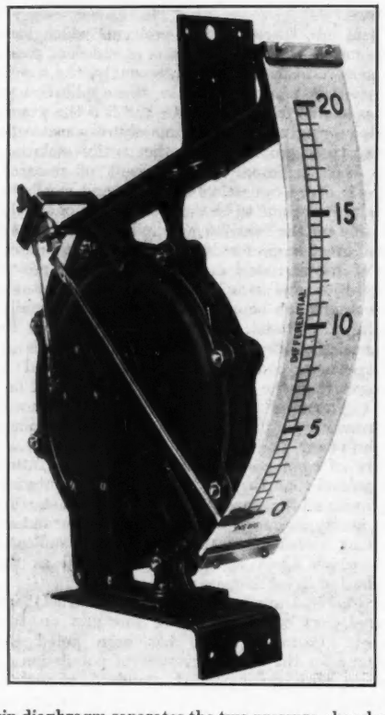
Calcul des Constructions Hyperstatiques: La Methode de Hardy Cross et ses Simplifications.

By SERGE ZAYTZEFF. Second edition. Dunod, 92, Rue Bonaparte, Paris, 6e. [Price 1,420 francs.]

IN the first edition of this book, which was published in 1951, the author explained and exemplified the Hardy Cross procedure of analysing structural frames, and did so with a breadth of outlook and conciseness of expression that rendered it of real value to all interested in the subject with which it dealt. In the second edition, the original text has been amplified by the incorporation of bibliographical notes on other sources of reference, and by the addition of new matter in two appendices at the end of the book. The blending of theory with practical requirements is neatly accomplished in Appendix I, where the slope-deflection method of Wilson and Maney is brought into close relation with the moment-distribution method of Hardy Cross. This comparison of methods provides further support to one of Mr. Zaytzeff's main theses: "La méthode de Hardy Cross doit être classée parmi les méthodes analytiques exactes et ayant l'avantage de simplicité et rapidité des opérations de calculs." In this edition there is also a novel and extremely useful method of dealing with Vierendeel trusses subjected to a combination of unsymmetrical deflections in the vertical and horizontal directions. Experience as an engineer has evidently impressed him with the need of discrimination in the choice of the tabulated data and diagrams to be included in Appendix II. These tables, which occupy 40 pages, place at the disposal of designers a mass of information based on the relevant investigations of Hardy Cross, Prenzlow, Ling, Casado, and the author. The book is written, in the first place, for engineers, and while it introduces the student to advanced parts of the formal theory, the simplest explanations are given of the more elementary ideas, so that it may be recommended to all classes of readers. It will be consulted, no doubt, by those responsible for courses of study in engineering colleges and universities.

DIFFERENTIAL DRAUGHT GAUGE.

A DIAPHRAGM-OPERATED differential draught gauge has been added to the range of combustion-control instruments manufactured by George Kent, Limited, Luton, Bedfordshire. Its main features can be seen in the accompanying illustration. Being of simple construction, it can be used even on very small boiler plants; one application is to give the load across a pulverising mill. The lamb-



skin diaphragm separates the two pressure chambers and is held in place by two springs. The spring in the upstream chamber ensures that the movement is in the right direction, while the other is calibrated to give the instrument its range. The motion is taken through a pressure-tight gland to the linkage which operates the pointer. An adjusting screw sets the zero position. Translucent scales can be fitted when internal illumination is required. An accuracy of ± 2 per cent. of the maximum differential head is guaranteed. The whole unit is contained in a dust-proof and fume-proof casing. Ten ranges are made, the maximum differential pressure being 30 in. of water.

THIRD PROGRAMME TRANSMITTER AT DAVENTRY.—Owing to a fault on the main aerial system, the Third Programme Transmitter of the British Broadcasting Corporation at Daventry has recently been operating at reduced power on the reserve aerial. The main aerial was, however, again brought into use on Thursday, September 10.

150-MW. POWER STATION AT SINGAPORE: ERRATUM.—We regret that in our description of the new 150-MW power station at Singapore, which appeared on page 283, *ante*, it was stated that the circulating-water pumps were supplied by Messrs. Drysdale & Co., Ltd. These pumps, of which there are ten, were, however, actually manufactured by Messrs. Vickers Ltd., London, S.W.1.

HYDRO-ELECTRIC DEVELOPMENT IN NEW ZEALAND.—According to the State Hydro-Electric Statement for the year ended March 31, 1952, the total installed capacity of the 25 hydro-electric stations in New Zealand at that date was rather over 701 MW, compared with 675 MW a year earlier. There were also six steam and 17 oil-engine stations, the aggregate installed capacity of the former being 58 MW and of the latter nearly 20 MW. The total connected load, excluding bulk supply, was 5,430 MW, compared with 4,949 MW and the total output 3,462 million kWh.

BOOKS RECEIVED.

Fundamentals of Physical Metallurgy. By PROFESSOR RALPH HULTGREN. Macdonald and Company (Publishers), Limited, 16, Maddox-street, London, W.1. [Price 70*s.* net.]

The British Electrical and Allied Industries Research Association. Technical Report No. G/T 262. *Gas-Blast Circuit-Breakers. Effect of Arcing on the Mass-Flow of Air Through the Nozzle and on Nozzle Pressure.* (Second Progress Report.) By A. A. HUDSON. [Price 6*s.*] No. L/T 247. *The Dielectric Properties of Silicone Liquids.*—II. By E. RUSHTON. [Price 4*s.* 6*d.*] No. L/T 271. *Discharges in Dielectrics at High Voltages and in the Presence of Harmonics.* By J. H. MASON. [Price 12*s.*] No. M/T 116. *Measurement of Radio Interference in the Frequency Range* 0·15 *to* 30 *Mc/s. A Portable Measuring Set.* By S. F. PEARCE and D. C. G. SMITH. [Price 10*s.* 6*d.*] No. M/T 117. *Measurement of Radio Interference in the Frequency Range* 0·15 *to* 30 *Mc/s. A Mains Isolating Unit.* By J. MIEDZINSKY and S. F. PEARCE. [Price 12*s.* 6*d.*] No. V/S 1. *Recommended Definitions of Terms Used in Power System Studies.* [Price 15*s.*] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Productivity Report. Fuel Conservation. Report of a Visit to the U.S.A. in 1952 of a Specialist Team on the Conservation of Fuel, Heat and Energy. British Productivity Council, 21, Tothill-street, London, S.W.1. [Price 5*s.*]

British Electricity Authority. Dust Sampling Equipment. Secretary's Office, British Electricity House, Winsley-street, London, W.1.

Commonwealth of Australia. Fourth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the Year Ending 30*th June*, 1952. L. F. Johnston, Commonwealth Government Printer, Canberra, Australia. [Price 10*s.*]

Basic Mechanics of Fluids. By PROFESSORS HUNTER ROUSE and J. W. HOWE. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 36*s.* net.]

Overseas Economic Surveys. Denmark. By S. SIMMONDS. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* 6*d.* net.]

TRADE PUBLICATIONS.

Bulldozers and Scrapers.—The Birtley Co., Ltd., Birtley, Co. Durham, have published a coloured brochure giving brief specifications of their bulldozers and scrapers. These are specially designed for use with "Caterpillar" tractors.

Automatic Control Valves.—An abridged general catalogue issued by the Fisher Governor Co., Ltd., Century Works, London, S.E.13, gives particulars of the British-made Fisher equipment now available. This includes diaphragm control valves, pressure regulators and level-control equipment capable of dealing with pressures up to 1,500 lb. per square inch at 800 deg. F.

Overhead Cranes.—A copiously-illustrated brochure from the Clayton Crane and Hoist Co., Ltd., Irwell Chambers, Union-street, Liverpool, 3, gives particulars of their electrically-operated overhead cranes and hoists. Special mention is made of the "Micro Speed" unit which, in conjunction with the main motor, gives an extra low-speed range for fine operations. The hoists are shown in use in ordinary cranes and also in conjunction with telpher lines.

Variable-Speed Units.—Kopp Variator stepless variable-speed units are described in pamphlets issued by Allspeeds, Ltd., 59, Park-road North, London, W.3. Transmission capacities range from ¼ to 6 h.p. and output speeds from 5 to 4,000 r.p.m. Complete motorised units can be supplied, fitted with either electrical or mechanical remote-control gear.

Diesel-Electric Locomotives.—In an illustrated leaflet, Baldwin-Lima-Hamilton Corp., Philadelphia, Pa., U.S.A., give general specifications for their standard Baldwin-Westinghouse Diesel-electric locomotives. Seven general types are listed, ranging from 1,200 h.p. to 2,400 h.p. The freight types may be operated as multiple units to provide up to 6,400 h.p.

Drilling Heads.—Five motorised drilling heads with capacities from ¼ in. to 1 in. are described in a leaflet issued by W. J. Meddings, Ltd., Slough Estates House, 16, Berkeley-street, London, W.1. Two arms, suitable for fixing to a vertical surface such as a wall or stanchion, on which the drilling heads may be mounted, are also described. The longer arm, with a radius of 48 in., can turn about its own mounting, but the shorter, 32 in. long, is fixed. The drilling heads can also be rotated about their own mounting, giving a very flexible set-up. This leaflet also shows some multi-spindle attachments. Another leaflet gives details of a transparent chuck guard for these machines.